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Curriculum in mathematics for air conditioning and refrigeration

Darrow P. Soares

CURRICULUM IN MATHEMATICS FOR

AIR CONDITIONING AND REFRIGERATION

A Project

Presented to the

Faculty of

California State University,

San Bernardino

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

in

Education: Vocational Option

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ABSTRACT

In the last two decades the work environment and the proficiencies required to function in it have changed. Accumulated literature argues that our traditional, stratified educational system has not prepared the workforce for the changes that have occurred in the work-place. Both high school and college graduates require similar outcomes: the competencies to achieve employment and the educational foundation to continuously upgrade their knowledge and skills. Specific changes in curriculum must occur if the U.S. educational system is to meet this challenge. Specifically, academic dualism between the Applied Sciences and the Pure Sciences must end and the scientific and mathematical foundation of vocational students must improve. In addition, collaboration between school faculty members and business leaders must be established which results in relevant curriculum and work-sight learning.

The purpose of this project was to develop a curriculum taught in collaboration with the Math Department specific to the trade of air conditioning and refrigeration at Mount San Antonio College. In collaboration with community leaders and the Math Department faculty, this curriculum was developed to provide students with the skills needed to enter the trade of air conditioning and refrigeration and the foundation for continuos learning in any occupational specialty.

The curriculum for a Math Lab for Air Conditioning and Refrigeration was written and approved by the Air Conditioning and Refrigeration Advisory Committee and the

Academic Senate Curriculum Committee at Mount San Antonio College. A team, however, of faculty members crossing academic and vocational education was never developed. The primary reason for this lack of collaboration was the culture of the academic environment that keeps departments specialized and separated.

The project writer strongly believes that the standards at which vocational courses are taught must increase. The project writer recommends that vocational instructors be made responsible for increasing their own knowledge of the humanities, mathes and sciences in order to infuse that knowledge into the vocational curriculum.

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To my wife who introduced me to the importance of public education and the honor of serving in it. Her actions influenced me to set all aside and pursue teaching as a career.

TABLE OF CONTENTS

Chapter I

Introduction

A separation between academic and vocational education has long existed in the United States. This division has resulted in different educational standards for those students planning to attend college, and for those students planning to enter a skilled trade. The justification for these academic and vocational divisions is based upon the assumption that industrial economies require a separation of mental and manual labor. The United States economy, however, has shifted from an industrial based economy, to an economy reliant on information (Berryman & Baily, 1992; Carnevale, 1991). The outcome of this issue becomes significant when considering the volumes of literature devoted to academic dualism and its effects on society and the economy.

Academic dualism in the United States can be traced back to the early colonies of New England. Willisten (1894) noted the early social differences caused by the status of students attending New England colleges and secondary schools established by the Puritans as compared to the social status of those involved in apprenticeship training. The Puritans recognized the relationship between literacy and the success of their religious faith. This ideal was a natural outcome of the importance the Puritans attached to the Bible and the religious truths it uncovered. The ability to read Biblical scriptures and then apply literacy to other forms of information enabled the Puritans to gain an early social lead in the Colonies (Williston, 1894).

In the 1750s, education in the Colonies was expanded when the New England academies were developed in Philadelphia by Benjamin Franklin. Franklin stressed that additional subjects should be considered practical or utilitarian. These subjects included navigation, surveying, mathematics, and science. Although the academies did expand the range of subjects taught in the classroom and widened the scope of education in the Colonies, the academies were distinctly different from the New England colleges formed by the Puritans that focused on philosophy, literature, and Latin (Butts & Cremlin, 1953).

According to Edward Krug (1969), modern separation between academic and vocational education may be rooted in two events. The Morrill Act of 1862 granted land to the states for the creation of agriculture and mechanical schools. Although the law elevated the status of agriculture and the mechanical arts, it also served to physically separate high school students entering a vocation from high school students bound for college. In addition, the law called for specially trained instructors to teach a skilled trade. Krug (1969) concluded that this event began the process of focusing occupational related curriculum on job training rather than general education.

The second important event, according to Krug (1969), was the 1892 report by members of the National Education Association (NEA) that sought to define the relationship between secondary and higher education by focusing on the requirements for college admission. The final report of the committee identified nine curriculum areas as the modern academic subjects by which college admission would be based. The curriculum areas were identified as (a) Latin, (b) Greek, (c) English, (d) other modern languages including French and German, (e) mathematics, (f) physics including astronomy, and chemistry, (g) natural history including biology, zoology, botany, and physiology, (h) history including civil government and political economy, and (i) geography including geology and meteorology (NEA, 1893). Although the nine curriculum areas identified by the NEA members expanded the curriculum by recognizing the equality of the subjects identified and widened the background of the college bound student, the NEA report isolated vocational curricula from the college bound student and reduced the importance of occupational related subjects (Krug, 1969).

Haney (1907) further separated academic and vocational education when he wrote that effective school systems should organize vocational courses for boys in the lower grades who are less academically talented. Although Haney (1907) was proposing vocational education as a solution to truancy problems, it was implied that vocational education was for the less academically talented.

Currently, the educational system in the United States continues to divide the student population into two groups: one group planning to earn a baccalaureate degree, and another group preparing to enter the workforce after high school. For the baccalaureate bound, the curriculum has traditionally been wide with emphasis on general education rather than application. According to Thomas Bailey (1991), college graduates from the United States tend to be highly disciplined, but lack the competencies to enter employment without additional basic training at the expense of the employer (Bailey, 1995).

The curriculum for those entering the work force after high school, has been the opposite of the curriculum for the college bound student. Students on a vocational tract had the option of occupational programs which offered tangible skills that resulted in job specific competencies. Ogden (1990) observed that vocational programs offering entry level job skills have often been the solution to the drop-out problem in secondary schools. The notion that students who cannot work with their minds can work with their hands continues to be common (Ogden, 1990). The result, for vocational students, has been a narrow education that inhibits innovation and life-long learning (Cappelli, 1992; Berryman & Bailey, 1992).

In the last two decades the work environment and the proficiencies required to function in it have changed. These changes have resulted from corporate down-sizing, shrinking business cycles, intensified global competition, and new technologies. New responsibilities for non-managerial workers have emerged in the form of information management, increased scientific and technical knowledge, and continuos learning. According to Carnavale (1991), in the past these responsibilities were reserved for management since U.S. business was based on the 19th century notion that management and labor had separate tasks. As the ranks of U.S. businesses thin, however, these responsibilities have become less distinct. As a result, a career of working at a specific job consisting of specific tasks is becoming obsolete. Workers must be willing and able to learn new tasks and assume new responsibilities out of their traditional job descriptions if they are to remain valuable employees (Carnevale, 1991).

Accumulated literature argues that our traditional, stratified educational system has not prepared the workforce for the changes that are now occurring (Berryman & Bailey, 1992; Carnevale, 1991; Carnevale & Porro, 1994; Drucker, 1994). According to Berryman and Baily (1992), college graduates require more application and less theory and high school graduates lack breadth of education and life-long learning skills. Both high school and college graduates require similar outcomes: the competencies to achieve employment and the educational foundation to continuously upgrade their knowledge and skills (Berryman & Bailey 1992; Carnevale 1991).

The community college offers the perfect niche to deliver employable skills and the educational foundation for life-long learning. However, specific changes in curriculum must occur if the community college system is to meet this challenge. Specifically, academic dualism between the Applied Sciences and the Pure Sciences must end and the scientific and mathematical foundation of vocational students must improve. In addition, collaboration between school faculty and business leaders must be established which results in relevant curriculum and work-sight learning. These reforms will serve purposes that are critical to the modernization of the workplace and to the new responsibilities of employees.

Significance of the Project

According to Carnevale and Porro (1994), reform of schools and the modernization of the workplace are inextricably linked. Carnevale and Porro (1994) argue that the competitiveness of U.S. business and industry depends on the ability of workers to use and build upon knowledge learned originally in school. In 1983, the National Commission on Excellence in Education (NCEE) was formed to evaluate the quality of education and learning in U.S. schools and colleges. The formation of the NCEE was requested at a time when our educational system was "seriously considered remiss" (NCEE, 1983, p.1). The U.S. public saw the state of education as a major factor in the deterioration of U.S. products and U.S. global competitiveness (Beck & Namuth, 1988).

The writers of the NCEE (1983) report associated the mediocre educational performance of the nation with an act of war and an act of unthinking educational disarmament against the ability of the U.S. public to remain globally active. The NCEE (1983) members identified a strong correlation between the decline of quality education and the standard of living in the United States. In addition, the NCEE (1983) members predicted a decline in the U.S. standard of living unless all segments of our population focus on educational reform.

In a report to The National Assessment of Educational Progress, Venezky, Kaestle and Sum (1987), claimed that 30% of adolescents and young adults in the United States lacked the basic literacy skills required to collect information from different parts of a document in order to make sense of an unfamiliar task. Venezky et al. (1987) reported that only 56% of 17 year olds in the U.S. could compute with decimals, fractions, and percents or recognize geometric figures. Venezky et al. (1987) also stated that only 54% of 17 year olds in the U.S. could solve simple equations or use moderately complex reasoning and that only 43% of 17 year olds in the U.S. have enough scientific knowledge to evaluate the appropriateness of scientific procedures.

In a study of the garment industry, Baily (1988), indicated that poor literacy and mathematical skills reduce the ability of an employee to find and hold a job that pays enough to support a family. Bailey (1988) reported that textile companies often recruited machine operators to act as mechanics. These machine operators usually had little formal education, but they were able to make the transition into the garment business with informal on-the-job training since the mechanical technologies that the machinist were used to were similar to the technologies faced in the garment industry. In recent years, business leaders have introduced various forms of automation based on microprocessors and electronic components. This new technology has allowed the garment workers to speed production and produce more customized products. Repairing this new equipment requires mechanics to follow detailed manuals and refer to updates from manufacturers. As a result, many of the former machine operators were unsuccessful in learning the digital and microprocessor components since they lacked the literacy skills to make the transition (Bailey, 1988) .

Berryman and Bailey (1991) documented accounts of firm based training that taught employees basic science and math skills required in the textile industry. In 1987, Swift Textiles, the largest denim manufacturer in the world, carried out a major modernization program in its Columbus, Georgia plants. At the same time, the firm was investing in new forms of automation in order to anticipate market changes, and establish a system of quick response. One of the changes caused by the new upgrades was an immediate need for trained personnel to repair and maintain the new equipment. Swift designed a training course to teach students the use of a calculator to solve algebraic equations using formulas required in manufacturing that included basic electricity, the gas laws, and tolerances of machine parts. The course consisted of 15 three-hour classes. Of the 32 students who entered the first class, only six successfully completed the course. Berryman and Bailey (1991) concluded that most of the students who failed to complete the course did not have an adequate background in math.

In the years since A Nation at Risk, policy makers have realized the need to bring the schools and the workplace closer together. In 1990, the Bush Administration developed the America 2000 Educational Strategy in order to develop a new generation of U.S. school administrators who emphasized higher standards, accountability, and access to a positive learning environment for all students attending school. America 2000 was an ambitious nine-year strategy that included the construction of 535 new schools that would close the U.S. skills-and-knowledge gap. Although it advocated a strong back-to-basics philosophy, an important component of America 2000 was the need for school and business to work together in developing curriculum and educational outcomes. In June of 1992, the U.S. Department of Labor released a report by The Secretary's Commission on Achieving Necessary Skills (SCANS). The writers of the SCANS report spelled out the skills required of young people to succeed in the workplace on a life-long basis. The emphasis the SCANS writers placed on life-long learning and personal responsibility reflected changes they perceived taking place in the workplace.

In 1994, U.S. President Bill Clinton developed a set of national goals and objectives for the states to achieve in meeting the reform called for in three documents: A Nation at Risk, America 2000, and SCANS. Clinton declared it time to abolish the outdated distinction between academic and skill learning. President Clinton noted that the United States had failed for too long to give young people the opportunity and tools to make the critical and challenging transition from school to a first job with a future (Weekly Compilation of Presidential Documents, 1994). The President enacted Goals 2000: Educate America Act and soon after, The School to Work Opportunities Act of 1994 as the new blue print for schools in the U.S. Signed into law 12 days apart, the new laws emphasized the willingness of the Clinton Administration to follow up with the educational concerns of the Reagan and Bush Administrations (Sowell, 1994). The new laws included an emphasis on national skills standards, the end to academic dualism, strong collaboration between business and the school, and accountability on the part of educational providers.

With the Republican Congress taking control in 1995, legislation in both the House and the Senate was proposed to repeal the laws passed by previous administrations. Legislation has sought to consolidate the masses of job training and education programs offered by government and combine them into block grants administered by the states. The philosophy of the 38th Congress did not affect the theme of educational reform as much as the ideal of individual control by the state over accountability and funding (McCallum, 1995). The theme of educational reform and the basic philosophy of ending academic dualism, the formation of school and business partnerships, and accountability of education providers have transcended party lines. According to McCallum (1995), the basic direction of educational reform had not changed in three administrations.

Statement of the Project

A curriculum for air conditioning and refrigeration was developed to bridge the gap between applied learning and academic learning. The course was specifically designed for students enrolling in courses for air conditioning and refrigeration but have not taken high school algebra or who do not qualify for MATH 71-Intermediate Algebra at Mount San Antonio College. The curriculum for this project consists of a syllabus, 16 lessons, 38 lab projects, a midterm, and final project. Quiz development and scheduling will be the responsibility of the instructor based on the level and needs of the class. The design of the curriculum was be approved by the advisory committee of the Air Conditioning and Refrigeration Department at Mount San Antonio College and The Academic Senate Curriculum Committee.

Purpose of the Project

The purpose of this project was to develop a curriculum in collaboration with the Math Department faculty specific to the trade of air conditioning and refrigeration at Mount San Antonio College. Through the development of this curriculum, and collaboration with community leaders and the Math Department faculty, this curriculum was developed to provide students with the skills needed to enter the trade of air conditioning and refrigeration and the foundation for continuos learning in any occupational specialty. The goals of this project are to participate in educational reform by developing curriculum that blends academic and practical learning, and develops and maintains strong ties between Mount San Antonio College faculty and the community leaders involved in air conditioning and refrigeration.

Limitations and Delimitations

The limitations and delimitations of the project are presented in the next section.

Limitations

1. This project was limited since the participation of curriculum integration at Mount San Antonio College was confined to faculty members committed to educational reform and innovation. Individually, faculty members from each department supported the philosophy of integration. When an

opportunity to participate in integration was available, almost all departments opposed it collectively. Therefore, resources to form partnerships were limited.

Delimitations

1. The participants in this project were delimited to Math Department faculty, the Air Conditioning and Refrigeration Department faculty at Mount San Antonio College.
2. The content for the math lab in air conditioning and refrigeration was extrapolated from existing curriculum at Mount San Antonio College to include: (a) elementary algebra-MATH 51, (b) electrical fundamentals for air conditioning and refrigeration-AIRC24 (c) refrigeration fundamentals-AIRC20, and (d) mathematics for industrial technology-MFG 70. Additional material was extracted from elementary algebra text books, text books for air conditioning and refrigeration, and air conditioning and refrigeration trade journals.

Definition of Terms

The following terms are defined as they apply to this project:

Academia--those individuals employed within a school system or closely associated with school policy making.

Academic Education--a curriculum that focuses on subjects required to gain entry into a four year college or university.

Academic Dualism--a condition that refers to separate standards of education between academic and vocational education.

Applied Science--those courses offered that result in practical applications and work related knowledge.

Curriculum--a set of courses offered by an educational institution consisting an area of specialization.

Curriculum Integration--a method of combining general education curriculum with occupational curriculum to raise the educational standards of vocational students.

General Education--those courses required for transfer to or graduation from a four year college or university not directly associated with the students major.

Global Competition-- refers to a condition where U.S. business and industry must compete with international business and industry for both domestic and foreign markets.

Global Economy--refers to a condition where economic conditions are effected by international economies as well as domestic economies.

Industry-- those individuals and corporate entities with a stake hold in the private sector of the economy.

Integration--the process of blending general education curriculum with occupational curriculum to increase the academic standards of vocational students.

Learning Styles--refers to a condition where students are motivated to learn under different conditions or circumstances outside of the traditional educational environment.

Literacy Skills--refers to the competencies required to translate written information into useful concepts or tangible skills.

Multidisciplinary Courses--those educational courses that infuse curriculum from different specializations to create one common course.

Non-traditional Students--those post secondary students not fitting the common image of baccalaureate bound students. Students falling into this category are those returning as older adults, pursuing an occupational skill, or are an ethnic minority.

Production Flexibility--a condition that allows business or industry to react to rapid economic change and quickly shift production strategies to meet unpredictable consumer demands.

Situated Learning--learning that focuses on making the educational environment resemble the work environment through structured work problems and technological solutions.

Skills Gap--a condition that defines the contrast between the technological needs of business and industry and the level of education of the available workforce.

Technology--refers to a method of achieving a practical purpose based on laws and principles taken from mathematics and science.

Vocational Education--a curriculum that focuses on the skills and knowledge required to gain entry level employment in a specific job or trade.

Organization

This project is divided in five chapters. Chapter 1 provides an introduction to the problem, significance of the project, statement of the project, purpose of the project, limitations and delimitations, the definition of terms. Chapter 1 ends with the organization of the project. Chapter 2 consists of a review of the literature, and the various approaches of integrating academic and vocational education. Chapter 3 outlines the methodology and defines the population served and concludes with a summary. Chapter 4 contains the verification of the project, the project design and a summary of the chapter. Chapter 5 presents the conclusions of the project, offers recommendations and concludes with a summary.

Chapter II

Review of Literature

The contents of this chapter include the changes that have occurred in business and the work-place that have resulted in high levels of critical thinking skills for employees in manufacturing and the skilled trades. As a result of these changes, documentation is offered to illustrate a rise in technical labor requirements needed to meet the challenges of a global economy. Further, it contains a discussion of how the traditional educational system in the United States is inadequate to meet the demands of a global economy and discusses the efforts being made at educational reform.

Roots of the Changes in the Nature and Structure of the Workplace

In 1983, the publication of A Nation At Risk launched a wave of debate over the effectiveness of the U.S. educational system. Business and industry argued that the academic community had become disconnected from the needs of the business community because it had lost tract of the demands placed on the schools by the new global Economy (Carnevale, 1991; Hoyt, 1991; Pajak, 1993). Members of the academic community, on the other hand, warned against blind reliance on business cycles and market like mechanisms to define public good and educational goals (Giroux; 1989, 1991; Helm, 1995; Pew Higher Education Roundtable [PHER], 1994). With this difference in opinion, it appeared that communication was required to find a common ground between the academic community and the business community.

The conflict between academia and industry began to surface by the late 1970s (Berryman, 1992; Carnevale, 1991). Business and industry were being squeezed by the advent of new technologies and new sources of competition from abroad. These new forces pushed U.S. business out of a comfort zone created by the domestic post-World War II boom. As a result, businesses in the United States were forced to compete with new, flexible industries emerging in Asia and Europe after being rebuilt (Carnevale, 1991; Berryman & Bailey, 1992).

Research by Edwards (1979) and Hall, Johnson, and Turney (1990) indicated that businesses leaders in the United States relied on mass production and guaranteed consumer demand. Hall et al. (1990) stated that the success of the United States was measured by the ability of U.S. workers to produce higher volumes of goods and services with the same or fewer resources than the foreign competition. The demand for U.S. consumer goods following World War II, combined with a manufacturing base built for war production pushed U.S. productivity to unprecedented levels. Edwards (1979) stated that the U.S. postwar boom was based upon the ability of the U.S. to produce higher volumes of goods and services with the same or fewer resources. With guaranteed domestic demand, U.S. industry was able to reduce the costs of manufactured units simply by increasing the volume produced. This strategy worked during the 1940s and 1950s when the U.S. market was eight times the size of the next largest domestic market. The domestic manufacturing capacity could be fully absorbed without going offshore and competing abroad. According to Edwards (1979), as long as consumer demand remained high and resources were plentiful, U.S. manufacturers were able to operate profitably with the manufacturing infrastructure and production methods developed for the World War II effort, but only meeting the needs of domestic U.S. markets.

In a study of the automobile industry, Womack (1989) determined that Europe and Japan's domestic markets were never large enough to emphasize the high-volume production of automobiles for domestic sales alone. As a result, European and Japanese auto makers adjusted to the complexity of the international automobile market early on (Womack, 1989). German and Japanese automakers not only produced cars for their domestic markets, but also had to satisfy the styles and conditions found well beyond their boarders. According to Womack (1989), the fragmented markets in Europe and Asia forced the Europeans and Japanese to focus on flexibility to provide a variety of products tailored to diverse market segments.

In addition, to compensate for their inability to match U.S. productivity, the Europeans and Japanese focused on quality. Since decreasing costs per unit of output by increasing volume was not an option, European and Japanese auto makers achieved alternative savings by reducing the cost of reworking products by increasing quality in production. Additional savings were achieved by focusing on effective work processes, flexible organizational designs, and superior integration of human and machine capital (Womack, 1989). With an emphasis on production flexibility and active work processes, the demand on the European and Japanese workers to react to change and to innovation was greater than workers in the U.S. who were rewarded for reducing costs by increasing output (Womack, 1989). The constant innovation required to compete with the U.S. industrial giants encouraged the Europeans and Japanese to carefully utilize human capital and focus resources on learning at school and on the job (Womack, 1989; Dertouzos, Lester, & Solow, 1989).

With the advent of new competition, U.S. business leaders were forced to react to rapidly changing markets, high quality foreign competition, and stock holders impatient for dividends. U.S. business leaders adjusted to the competition from abroad by investing in automation and technology and shedding skilled labor (Carnevale, 1991; Rosenberg & Birdsell, 1986). According to Murnane and Levy (1992), the logic of investing in automation was to increase production and quality while decreasing personnel costs. The Europeans and Japanese treated labor as a fixed cost of production and did not eliminate expensive labor by substituting machinery and unskilled labor. As a result, there were strong incentives for the Europeans and Japanese to use and develop personnel and labor when U.S. businesses leaders relied on specialty purpose machinery and unskilled labor to drive productivity (Murnane & Levy, 1992).

Japanese and European workers were well prepared for flexible work environments. Tan (1989) documented the emphasis on applied learning in Japan and Europe as more important than anywhere in the United States. Tan (1989) used examples of European apprenticeships and Japanese group processes in school and the strong emphasis on problem solving teams on the job in Japan and Europe as evidence of their applied focus. In contrast, according to Ogden (1990) it has been the U.S. practice to break down knowledge into theoretical disciplines, reduce disciplines into component pieces, and require students to commit fragmented knowledge to memory. Applied learning in the United States has been a matter of answering the questions at the end of a chapter and multiple choice tests (Ogden, 1990). In documenting U.S. educational history, Ogden (1990) stated that collaboration between disciplines has been rare, and applied learning to the work environment almost nonexistent. As a result, innovation in the work place was the responsibility of the managerial elite and creative processes began at the top and were delegated downward (Ogden, 1990).

Evidence of a New Technical Labor Force

The rapid growth of technology has brought about many changes in the Global Economy. Low skilled jobs are rapidly disappearing as society shifts from an industrial based economy to a technological and information based economy (Carnevale, 1991; Murnane & Levy 1992; Silvesrti & Lukasiewics, 1989). Drucker (1994), stated that as recently as the 1960s almost 50% of all workers in the industrialized countries were involved in some process of production. By the year 2000, no developed country will have more than one-sixth or one-eighth of its workforce in the traditional roles of making and moving manufactured products (Drucker, 1994). In 1950, 60% of the jobs in the United States could be performed by unskilled workers. By the year 2000, only 15% of the jobs in the U.S. will fall into the unskilled category. Based upon occupational employment records since 1900, and occupational projections until the year 2010 by Silvestri and Lukasiewics (1989), unskilled service occupations are growing at a slower rate than skilled and professional occupations. Service occupations showed a marginal growth of only 4% between 1900 and 1989. Growth in the clerical occupations made most of its gains before 1960 (Silvestri & Lukasiewics, 1989).

Since 1950, much of the growth in the labor force occurred among managerial, sales, technical, and professional occupations. Direct employment in the production of manufactured products peaked during the 1940s when 6 out of 10 workers in the U.S.

were employed either as craftspersons or as operatives and laborers. By 1988, the proportion craftpersons, operatives and laborers had fallen to 36% (Barley 1992).

Economic forecasts indicate that professional and technical occupations will continue to grow rapidly. By the turn of the century, professional and technical occupations should account for more employment than any other occupation (Silvestri & Lukasiewics, 1989). Between 1975 and 1990, the higher skill occupations grew two-and-a-half times as fast as the lower skill occupations. During the 15 years between 1990 and 2005, higher skilled occupations are expected to grow just under twice as fast as low skill occupations (Silvestri & Lukasiewicz, 1991). Professional and technical occupations may account for 20% of the workforce by the year 2000 (Bishop and Carter 1991), while over 25% of all new jobs created between 1990 and 2000 are anticipated to be professional or technical in nature (Barley, 1992).

Evidence of a Rise in Skill Requirements

A major factor in the growth of professional and technical opportunities has been technological change (Barley, 1992; Cappelli, 1992; Carnevale 1991; Pritchett, 1994). Programmable machines have replaced human skill in many manufacturing processes in the textile and auto industries (Bailey, 1988; Womack, 1989). The skilled machinist is being replaced by programmable logic controllers because the new technology improves precision and quality. In addition, programmable logic controllers allow faster setup and reprogramming which in turn enhances variety and customization of products. Investment in automated technology does not necessarily replace the technician. According to Spenner (1985), substantial evidence shows a growing importance of high-skilled jobs in the economy and increasing skill requirements in existing jobs. Spenner (1985) writes that an increase in technology does not automatically result in a decrease in human contributions to the manufacturing process. When the complexity of work increases, an equal increase in the quality of technical and human resources is usually required (Spenner, 1985).

The concept of a skills gap is a concern for business and industry leaders trying to keep abreast with technology. This concept implies that there is an increase in skill requirements that cannot be met by the current supply of labor. Members of Workforce 2000 (U.S. Department of Labor, 1987) addressed the issue of this mismatch between the skill level of the present labor force and the current demands placed on labor by business and industry . Another study by members of the Secretary of Labor's Commission on Workforce Quality and Labor Market Efficiency (1989) documented complaints by employers in finding workers with adequate basic skills, in spite of a plentiful supply of applicants. A report by The Office of Technical Assessment personnel (1990) predicted a mismatch between the existing labor force and skill requirements as industry shifts to the flexible production techniques described by Carnevale (1991).

Another important reason for the rise in skill requirements has been the importance of science to modern society. Price (1986) indicated that scientific knowledge has expanded exponentially since the 17th century. Price estimated that by the 1960s, scientific output has doubled every 6 to 10 years. This rate of growth has been much faster than all of the nonscientific and nontechnical changes in the progress of civilization (Price, 1986).

The continued emphasis on science can be credited to the realization that scientific and technical knowledge can generate profits (Barley, 1992). According to Barley, the commercialization of chemistry and physics in the last two decades has given rise to the industries on which our economy now depends: aerospace, automobiles, energy, pharmaceuticals, petrochemicals, and electronics. In addition, advances in the life sciences since World War II have largely underwritten the present health care industry. Recently, molecular biology has opened opportunities for new industries and have radically changed others (Barley, Freeman & Hybels, 1993).

The explosion of scientific knowledge brought a huge demand for applied scientific technicians and research scientists (Barley, 1990). The expansion of science not only enlarged the existing scientific fields, but also created new occupational levels. According to Barley (1990), two new technical occupational processes were created that have had a profound effect on the nature of the technical work force: specialization and subcontracting.

According to Barley (1992), breadth of knowledge is achieved at the expense of depth of knowledge, and vice versa. Barley (1992) argues that the amount of knowledge becomes more complex, scientists and other professionals find it increasingly difficult to remain generalists. Since specialists are more highly valued, most scientists and professionals have adopted a policy of specialization which results in an increased number of narrow subfields. This condition has resulted in an increased demand for professionals since few individuals can act alone on tasks that require both breadth and specialization. In technical and commercial occupations, Kurtz and Walker (1975) documented how overburdened professionals have sought to reduce their workloads by allocating routine duties to less-trained individuals. This concept is common in many technical fields where specific occupations like CAD operators, design technicians, and customer service representatives have developed around tasks that were discarded by higher level occupations.

Perhaps the most important force for the growth of the professional and technical workforce has been technological change (Cappelli, 1992). According to Silvestri and Lucasiewicz (1989), occupations related to computers continue to be among the fastest growing. By the turn of the century, computer related occupations are anticipated to provide employment for nearly two million people. Barley (1992) describes the effect of the computer on society as infrastructural. According to Barley (1992), infrastructure technologies are defined as the type of technologies that form the foundation of a society's system of production during a historical era. Barley (1992) credits the computer for having the same societal impact the combustion engine or electric power had during the industrial revolution. In the long run, the effects of computerization on existing occupations may be the most important stimulus for the mechanization of the workforce.

Background of Ideas Leading to Educational Reform

During the past several years, educators have been researching new ways to structure the learning experiences of students. The ultimate goal of this structure has been to help students develop the skills and knowledge necessary to solve problems and become independent thinkers and life-long learners (The Cognition and Technology Group at Vanderbilt [CTGV], 1993). Like other researchers, members of CTGV has been influenced by Whitehead's (1929) theory of inert knowledge (Brown, Bransford, Ferrara &, Campione, 1983; Porter, 1989; Scardamalia & Bereiter, 1985). Inert knowledge is knowledge that can usually be recalled when people are explicitly asked to do so, but is not used spontaneously in problem solving even though it is relevant (CTGV, 1993). Whitehead was instrumental in identifying inert knowledge and claimed that information conveyed in schools was most likely to be presented in ways that make it inert (Brown et al., 1983; CTGV, 1990).

Sherwood, Kinzer, Hasselbring, and Bransford (1987) illustrated inert knowledge when they surveyed college students on the application of logarithms. The students were asked (a) how logarithms make it easier to solve problems, (b) why logarithms were invented, and (c) to define an application for logarithms. According to Sherwood et al. (1987), most students surveyed had no idea of the uses for logarithms. The students remembered learning logarithms in school but thought of them only as math exercises performed to find answers to logarithm problems. The students treated them as difficult ends to be tolerated rather than as a tool that allowed a variety of problems to be solved (Sherwood et al., 1987).

John Dewey (1933) stressed the importance of viewing knowledge as a tool. Dewey (1933) argued that when people learn about a tool, they learn what it is and when and how it is used. Similarly, when students learn new information in the context of meaningful activities, learners are more likely to perceive the new information as a tool rather than as an arbitrary set of procedures or facts. Bransford, Sherwood, and Hasselbring (1988) have shown that one of the advantages of learning in problem solving contexts is that students learn how to use information. When learning in context, students acquire information about the conditions under which it is useful to know concepts and facts. In addition, Bransford and Heldmeyer (1983) reported the learning successes of young children depend on opportunities to learn in meaningful, socially organized contexts. In support of the findings by Bansford and Heldmeyer (1983), laboratory studies of adolescent cognitive processes indicate that meaningful, problem-orientated approaches to learning are more likely than fact-oriented approaches to overcome inert knowledge problems (Adams, Kasserman, Yearwood, Perfetto, Bransford, & Franks, 1988).

Anchored instruction is a solution to the inert knowledge problem (CTGV, 1990, 1992, 1993). The concept of anchored learning has its roots in the theories of Dewey (1933) and Gragg (1940). Dewey (1933) reasoned in favor of theme based learning and later Gragg (1940) added to the theme of Dewey (1933). Gragg (1940) argued for the advantages of case-based learning. In this model, Gragg (1940) used a variety of mini-topics or microcontexts that allowed the exploration of a specific subset of a larger subject called a macrocontext. Case-based learning allowed the exploration of a subject for extended periods of time from the perspective of many different disciplines (Gragg, 1940). The Cognition and Technology Group at Vanderbilt [CGTV] (1990) applied these principles to two programs based on anchored learning. The Young Sherlock Project and The Jasper Series were learning environments based upon characters in traditional and popular works of literature: Sherlock Holmes and Jasper Woodbury. In both cases, the project involved the development of applications that enabled sixth grade students to learn problem solving skills based on science, history, and literature based on the experiences of the primary anchor characters. The objective was to provide students the opportunity for sustained thinking about specific problems over long periods of time (CGTV, 1990). Findings by Van Hanegan, Barron, Young, Williams, and Bransford (1991) on the Jasper Series experiment, showed students who were not normally good at math can become very good at complex problem solving after working with projects similar to Jasper and Holmes after four to five class sessions (Van Hanaghan et al., 1991).

Garafalo and LoPresti (1993), organized a form of anchored learning around the college freshman curriculum at Massachusetts College of Pharmacy in Boston. Freshman electing a major in chemistry were encouraged to participate in a cluster of classes that included math, biology, chemistry, and English. Chemistry served as the primary anchor, or what Gragg (1940) termed the macrocontext. Pure science courses tend to be linear in the presentation as instruction moves from atoms to molecules, to cells and beyond. As a result, the integration efforts of Gartafalo and LoPresti (1993) led directly to a restructuring of each course. The new curriculum introduced concepts like energy and matter through discussions of general subjects in familiar circumstances. Gartafalo and LoPresti (1993) found that engaging students with tangible common examples eased the students into college level courses and introduced problem solving activities earlier in the students' education. To assess the impact of the curriculum, Gartafalo and LoPresti (1993) shifted the testing style away from recognition, recall, and the ability to plug-in calculations. Rather, the success of a student was based upon the ability to master concepts and develop critical thinking skills (Gartafalo & LoPresti,1993).

Comparison of freshman chemistry student performance for academic year 1991-1992 with that of two years prior to the introduction of an integrated curriculum showed a positive correlation between anchored learning and student success (Gartafalo & LoPresti, 1993). Student performance in freshman chemistry tended to decline in the second quarter with two to four times as many students declining as improving. By the end of academic year 1991-1992 the trend had reversed with about twice as many students showing improved performance compared to declining performance. Gartafalo and LoPresti (1993), attributed the results to changes in student behavior encouraged by the integrated, active learning approach

Research by Raizen (1989) can be used to summarize the need for educational reform. According to Raizen (1989), the traditional separation between traditional academic learning and occupational learning only exacerbates the cognitive process rather than clarify it. Research on anchored learning and situated learning produce evidence that learning through work process and learning across disciplinary subjects is an effective method of acquiring work-related knowledge and the foundation for life long learning (Resnick, 1987).

Approaches to Integrating Academic and Vocational Education

Grubb and Kraskouskas (1992) surveyed faculty and administrators at 295 community colleges and technical institutions in the United States to explore the methods being used to integrate academic and vocational education. Of 168 respondents, 121 faculty members and administrators reported that integration between academic and vocational education was occurring on their campus in some form. Grubb and

Kraskouskas (1992) contacted a sample of the campuses involved in integration and identified eight common methods used in community colleges and technical institutions in the United States to achieve the integration of academic and vocational education. Four alternative methods of integrating academic and vocational education are discussed based on the findings of Grubb and Kraskouskas (1992) and Grubb et al. (1996). These four methods are (a) general education requirements, (b) applied academics, (c) multidisciplinary courses, and (d) cluster courses.

General Education Requirements.

The most frequent form of integration is the requirement of general education for occupational students (Grubb & Kraskouskas, 1992; Horan, 1995). In this method students are required to take general education courses that are not modified to address the occupational interest of students. Within the institutions examined, communication skills, critical thinking and problem solving abilities, an understanding of civic responsibilities, and appreciation of the arts and humanities were common goals for general education requirements (Grubb & Kraskouskas, 1992).

According to Grubb and Kraskouskas (1992), links between general education and vocational programs are the most developed in schools that provide their students with guidance on the general education courses required for their occupational direction. A thorough effort to link these requirements occurred at the Pennsylvania College of Technology (PCT) in Williamsport. Faculty members at PCT decided that general education requirements should be based upon the skills required in the workplace and developed core competencies using the DACUM (Developing a Curriculum) Process

(Pennsylvania College of Technology, 1987). The DACUM process involves assembling practitioners from specific occupational areas and having them describe the skills required for entry level employment. Faculty then use these job descriptions to determine the core competencies students need to master to be successful in the work-place. According to Grubb and Kraskouskas (1992), the resulting competencies were not much different from those cited in the general education requirements outlined in many community college catalogs. However, the process by which they were developed and the goals of the general education requirements were more vocational (Grubb & Kraskouskas, 1992). Grubb and Kraskauskas (1992) agree that the PCT model is a positive effort to expose vocational students to core competencies. However, the model has not resulted in the integration of academic competencies and vocational education since the courses remain separate (Grubb & Kraskouskas, 1992).

Research by Patricia Cross (1976) indicate that non-traditional students in community colleges have difficulty linking academic competencies with vocational requirements. Research by Cross (1976) is based on studies in cognitive learning styles that indicate non-traditional students in community colleges are more likely to have field-dependent learning styles. The field dependent learner perceives information globally and relies on the integration of information from many sources to master concepts or tasks. Field-independent learners, however, are likely to deal with elements independent of their background and approach tasks in an analytical way, separating elements from background (Cross, 1976). According to Cross (1976), traditional methods of academic achievement require the separation of information from background, giving field-independent learners the advantage in traditional school situations.

According to Lankard (1992), common profiles of vocational students often include weak academic performance, inconsistent attendance, and strong insecurities about academic coursework. As a result, general education requirements are often an incomplete approach to integrating vocational and academic education (Lankard, 1992). General education may bring into occupational programs the content and skills associated with academic disciplines, but it places the burden for integration on students themselves, and may not reach the vocational and non-traditional students most in need of these abilities. According to Grubb, Badway, Bell, and Krakouskas (1996), the most promising approaches to curriculum integration place the responsibility for integration squarely on instructors, and create new courses and groups of courses that are different from what may currently be offered.

Applied Academics.

A second common approach to integration is the development of applied academic courses which take conventional academic subjects and infuse them into vocational areas. Applied academic courses adapt the content of academic subjects and use practical applications from specific occupations to form a link between academic and vocational education. The best-known example is Writing Across the Curriculum (WAC), in which academic and vocational instructors are encouraged to incorporate more writing into their courses. Grubb et al. (1996) described how government administrators in Florida have required WAC in all of its community colleges. Initially, faculty were motivated to participate in WAC through recruitment and outreach. Members of the WAC staff conducted seminars to show instructors how to incorporate writing exercises into their courses. Faculty members not volunteering to participate were forced to do so by state mandate. A successful, less coercive method of motivating WAC participants succeeded at Kapiolani Community College (Hawaii). In this example, WAC was introduced to faculty as a way of teaching their occupational subject while allowing the student to earn credit for writing-intensive English courses. Courses that counted as writing-intensive included occupational courses such as Business/Management Writing, Basic Nursing Concepts, Introduction to Physical Therapy, and Special Radiology Procedures (Grubb et al. 1996).

Grubb and Kraskouskas (1992) and Statz and Grubb (1991) referred to a common conflict when developing curriculum for applied academics. When attempting to infuse subject areas, faculty members were often at odds whether an applied academics course should stress the abstract, theoretical side of the subject, including discipline-based modes of thinking, or if the course should limit the attention to academic content and stress occupational examples. Grubb and Kraskouskas (1992) documented a case at Bunker Hill Community College (Boston) in which a business math course was initially taught by business instructors. However, the math department thought the course was inadequate and refused to assign the course a math department number. Finally, the business and math faculty collaborated in developing a course worthy of being included among the math offerings. Statz and Grubb (1991) reported a similar conflict when developing a class in Applied Math for Recording Technology at Cedar Valley Community College in Lancaster, Texas. These examples of conflict between academic and vocational departments demonstrate existing tension and suggests that collaboration is crucial to successful infusion of academic and vocational education (Grubb & Kraskouskas, 1992; Statz & Grubb, 1991).

Apart from faculty rivalries, there may be another drawback to infusing academic courses into vocational programs. Occupational students tend to become segregated from others when enrolled in applied academics courses. Segregation could result in a form of tracking that could limit student ambitions (Grubb et. al., 1996; Grubb & Kraskouskas, 1992; Lankard, 1992; Statz & Grubb, 1991). In Grubb and Kraskouskas (1992), the dean at Bunker Hill Community College (Boston) explained the opposition to such courses by stating that occupational students need to have a broader exposure by associating with students from other disciplines. In addition, Bunker Hill faculty members found that applied English classes isolated students and focused them too much on their technical area (Grubb and Kraskouskas,1992).

Bunker Hill Community College students also demonstrated dissatisfaction with applied academic courses. Grubb and Kraskouskas (1992) found that applied academic courses evolved into remedial instruction in areas where students were weak. As a result, the students perceived the courses as adult basic education and rejected the format. Grubb and Kraskouskas (1992) concluded the rejection was based on the notion that applied English classes were remedial, insulting to students, and segregating.

The literature is replete with empirical evidence that science and math students improve academic performance through applied learning (see Brown et al., 1983; CTGV, 1990, 1992; Dewey, 1933; Garafalo & LoPresti, 1993; Sherwood et al., 1987). With the exception of Cross (1976) most literature on applied learning at the vocational level tends to be hortatory rather than empirical. Research by Cross (1976) implied that applied academics may be more compatible with vocational education students since many occupational students displayed field dependent learning styles. As a result, there is little quantitative evidence that applied learning for vocational students has improved their academic performance or enhanced their occupational performance once they are employed.

Multi-Disciplinary Courses.

Another approach to integrating academic and occupational education has been to introduce units of material taken from academic disciplines into standard occupational courses. The results are courses that can be included in general education programs with subjects of special interest to occupational students. These courses emphasize general skills of critical thinking and writing, but do not necessarily reinforce academic competencies required for employment. Multi-disciplinary courses tend to focus on political and social aspects of work and enhance the general education of the student.

According to research by Grubb et al. (1996), multidisciplinary courses commonly fall into one of several groups: (a) working life as a theme of literature, (b) science and technology as themes of literature, (c) the influences of technology on society, and (d) the perspectives of history, philosophy, and art to explore the effects of technology and production. The common element of these courses is the application of academic subjects that are reasonably more interesting for occupational students.

Most successful multi-disciplinary courses at the community college have been funded by the National Endowment for the Humanities or other NEH supported projects (Koziol and Grubb, 1995). The reliance on special funding is evidence of the resources required to develop multidisciplinary courses and other innovative approaches to teaching. Koziol and Grubb (1995), stress the need for staff development, since faculty must have release time to develop new materials and most multidisciplinary required the collaboration of faculty from many disciplines.

Cluster Courses.

A fourth approach to integration has been to develop a series of courses taken from academic and occupational subjects that students take simultaneously. Each course is designed to complement the other course. Clustering differs from traditional general education requirements by providing tangible links between the courses offered. The most effective approaches to curriculum integration place the responsibility for integration squarely on the design of the curriculum and on how the course is implemented (Grubb et al., 1996; Grubb and Kraskouskas, 1992; Koziol and Grubb, 1995).

Interaction between courses that result in clustering can be accomplished at several different scales. Occupational and general education classes can be linked, creating tandem courses that focus on a common outcome. Faulty members at Waukesha County Technical College (Wisconsin) paired Workplace Psychology with Welding, to integrate academic and vocational education. The result taught occupational students how race and ethnicity, safety, health, and interpersonal relationships affect the work environmen (Grubb et al., 1996). Also in Grubb et al. (1996), Linn-Benton Community College (Oregon) faculty integrated curriculum by pairing Business Quantitative Methods and Technical Report Writing.

At San Diego City College a cluster called History of Technology in the Workplace combines transfer level history, English, and computer information systems to focus on the theme of historical changes caused by technological advances. Also offered, Workplace Ethics and Communication Skills combine occupational perspectives with liberal arts studies in philosophy and with written and oral communications.

In all cases, students took courses simultaneously. Grubb and Kraskouskas (1992) reported that students within clusters were engaged deeper in the subjects than were most community college students. In addition, the students had stronger personal relationships, tended to work more collaboratively, and developed study groups and other support mechanisms that resulted in lower drop out rates. These opinions are consistent with the findings by Tinto (1987) that show dropout rates are lower among students whose social connections within postsecondary schools are strong.

Chapter 3

Methodology

Introduction

The contents of Chapter 3 describe how the project was developed. First, the rationale for selecting a team teaching approach is stated, second the population served and the course content is described. A mission statement specifying student outcomes are presented and the chapter will conclude with a summary.

Rationale for Selecting a Team Teaching Approach to Applied Academics

The applied academics model described in Grubb and Kraskouskas (1992), with a team teaching approach, was selected for two reasons. First, many secondary and post secondary school administrators and faculty have successfully utilized the model of applied academics in educational settings. In most cases where the model failed, failure was based on a lack of cooperation between the departments involved. Faculty members in the Math Department at Mount San Antonio College have expressed interest in educational reform and have contributed to the development of a math lab for air conditioning and refrigeration. Second, Barbara Crane, Dean of Instructional Services and Larry Schrock, Dean of Applied Sciences at Mount San Antonio College granted the project writer permission (see letter Appendix B) to develop curriculum for mathematics in air conditioning and refrigeration based upon an applied academics model with a team teach approach.

Population Served

The math lab for air conditioning and refrigeration-AIRC 10 was designed for students entering the trade of air conditioning and refrigeration with no prior experience in the industry. The course was specifically designed for students who have never had high school algebra or had deficiencies in first-year high school algebra, or who do not qualify for MATH 71-Intermediate Algebra at Mount San Antonio College.

The curriculum was extracted from courses at Mount San Antonio College to include MATH 51-Elementary Algebra, MFG 70- Technical Mathematics for Industrial Applications, AIRC 20-Fundamentals of Refrigeration, and AIRC 24-Electrical Fundamentals. The curriculum consists of formulas, operations with signed numbers, algebraic equations of the first degree, special products and factoring, algebraic fractions, ratio and proportion, and systems of linear equations as they apply to air conditioning and refrigeration. In conducting the project that led to the development of the AIRC 10 curriculum, the following resources at Mount San Antonio College were consulted: (a) Air Conditioning and Refrigeration Advisory Committee Members, (b) Math Department Faculty, (c) Barbara Crane, Dean of Instructional Services, and (d) Lawrence Schrock, Dean of Applied Sciences. Additional material was extracted from elementary algebra text books, text books for air conditioning and refrigeration, and air conditioning and refrigeration trade journals.

Summary

The contents of this chapter described how the project was developed. First, the rationale or the designed was described, followed by the population served, and a description of the course structure. The section concluded with a summary.

Chapter IV

Project Design

Introduction

The contents of Chapter 4 first describe how the project was verified. The design of the project is described and the chapter concludes with a summary.

Verification

Verification of the need for a math lab for air conditioning and refrigeration was based upon an extensive review of the literature. A review of the literature revealed a relevant need to integrate academic and vocational education. A math class focusing on the specific trade of air conditioning and refrigeration fits this need.

Design

The purpose of developing this course was to use mathematical concepts and language to learn the operational consistencies of air conditioning and refrigeration equipment. Students used equations that demonstrated the operation of electrical and mechanical equipment based on a variety of primary and secondary sources of information to include text books, journal articles, collaborative learning, and personal research.

The essential mathematical concepts of air conditioning and refrigeration can be grouped into three areas: (a) the mechanical side of refrigeration and air conditioning, (b) the electrical side of refrigeration and air conditioning, and (c) the air side of air conditioning and refrigeration. Students gather qualitative and quantitative information from existing mechanical and electrical equipment in order to make predictions about the operation of equipment and solve mechanical and electrical problems.

The fundamental assumption behind Math for Air Conditioning and Refrigeration is that the mechanical and electrical operation of air conditioning and refrigeration equipment is consistent and predictable through mathematical understanding. Students that connect mathematics with mechanical and electrical operation will have the foundation for life-long learning and the flexibility to adjust to new technologies.

Mathematics for Air Conditioning and Refrigeration was designed so that on a typical day, students observe the operation and effects of mechanical or electrical processes and then determine the mathematical reason for its operation. In order to reflect the nature of the workplace, students work in revolving groups and solve problems on a collaborative basis. Lab assignments are based on the manipulation of a mechanical and electrical processes that are initially observed by the student and later explained mathematically. Quizzes are taken individually. Upon completion of the quiz, students participate in work groups to determine collective solutions to the quiz questions. The average between the individual and the collective answers count as the overall quiz grade. Students are required to give one presentation on one process learned during the semester. All lab projects will be organized into a portfolio and submitted twice during the semester: at the midterm and at the final.

Summary

The contents of this chapter described the design of the project. The verification of need was described, followed by the course design and format. The section concluded with a summary.

Chapter V

Conclusions and Recommendations

Introduction

Chapter 5 presents the conclusions of the project and offers recommendations. The chapter concludes with a summary.

Conclusions

The curriculum for the Math Lab for Air Conditioning and Refrigeration was approved by the Air Conditioning and Refrigeration Advisory Committee and the Academic Senate Curriculum Committee. A team, however, of faculty members crossing academic and vocational education was never developed. The primary reason for this lack of willingness to team teach is a result of the culture of the academic environment at mount San Antonio College. Departments within an academic organization are established teams with a strong loyalty to the discipline. Faculty members work hard to be competent within the discipline and prestige is awarded faculty members who teach upper division classes in the subject area. Team teaching a subject outside of the normal discipline of the faculty would compete with the challenge and pursuit of remaining current in the primary field. The project writer was informed that a member of the Math Department team teaching a class in air conditioning and refrigeration would have to endure the cognitive process of learning the trade simply to teach a math class comparable to elementary algebra.

A second important cultural difference between academic and vocational programs is the product of what is taught. Academic classes within the Math Department are offered for transfer to a four-year university rather than specific job training. As a result, student successes or failures are measured by standardized testing. In the Air Conditioning and Refrigeration Department, the end product is a useable and transferable skill. The structure of the learning environment reflects the importance of developing usable knowledge by slowing or speeding the pace of the lessons to match the ability of students. When the project writer discussed this format with members from other departments, many faculty members viewed it as a compromise of both academic and professional standards.

Recommendations

The standards at which vocational courses are taught must increase. Based upon the review of literature, business and industry leaders require higher learning skills than what technical program faculty are currently offering. The answer may not, however, mean bringing faculty members from other disciplines together to learn each others subjects. Rather, it is the recommendation of the project writer that vocational instructors increase their knowledge of the humanities, math, and sciences in order to infuse the knowledge into the vocational curriculum. In order to increase the knowledge out side the subject area of vocational instructors, release time from committee work and the shared governance procedure must be granted. This additional time will allow motivated instructors to enhance their vocational curriculum by infusing the subject learned directly into their subject area.

Summary

Chapter 5 presented the conclusions of the project and offered recommendations. The chapter concluded with a summary.

AIRC 10

MATHEMATICS FOR
AIR CONDITIONING AND REFRIGERATION

SYLLABUS
&
OUTLINE

Developed by

Darrow Soares, MA
(1996)

Student:______________________________

Term:________________________________

Room:________________________________

Instructor:____________________________

Class Hours:___________________________

Office Hours:__________________________

Telephone:____________________________

E-Mail:______________________________

Mount San Antonio College, Air Conditioning and Refrigeration Department

Course Syllabus and Outline

Mathematics for Air Conditioning and Refrigeration

Course Description: A mathematical foundation applied to the procedures used in the trade of air conditioning and refrigeration. The mechanical, electrical, and air side of refrigeration and air conditioning will be explored mathematically in a laboratory setting.

Prerequisite: None

Required Text: Basic Vocational-Technical Mathematics 5th edition by Olivo & Olivo.

Require Material: Eye protection, note book for lab manual, and 15 foot tape measure. Students will not be allowed to participate in the lab projects involving electricity, refrigerants, or operational equipment with eye protection.

Grading:	Item	Percent of Final Grade
	Lab Assignments	30%
	Lab Manual	5%
	Quizzes	20%
	Presentation	5%
	Midterm	20%
	Final	20%

Lab Assignments. The purpose of the lab assignment is to reinforce the concepts discussed during the class session. Lab projects will be performed individually or collaboratively, depending on the type of assignment. Two or three lab assignments will be assigned each class session and are due at the beginning of each class session. Students requiring additional lab time beyond the normal class session, may attend open lab on Fridays from 1:00 pm to 4:00 pm. Lab assignments will be graded on accuracy, clarity, and punctuality. Lab assignments account for 30% of the total class grade.

Lab Manual. The lab manual is a record of the student's work and the student's understanding of the math principles. The lab manual will be turned in at the midterm and at the final and graded for organization. The lab manual accounts for 5% of the total class grade.

Quizzes. There will be six quizzes. Each student will receive a quiz with written situations that reflect mathematical problems encountered in the air conditioning and refrigeration industry and covered in class. Each student will work individually and turn the quiz in when completed. When all quizzes are turned in, the students will break into groups to readdress the quiz and decide on group solutions. The students final quiz grade will be an average of the individual score and the group score. Quizzes account for 20% of the total class grade.

Presentation. The presentation requires the student to demonstrate a practical application for math applied to the trade. The student may choose to clarify a project already performed in class or she may demonstrate a new application. Students wishing to participate in a presentation will get prior approval of both the subject and the time from the instructor. Presentations are optional, but accept for 5% of the total class grade.

Midterm and Final. The midterm and final will consist of a project completed outside of class. The midterm and the final will resemble the format of the lab projects, but will require an understanding of the mathematical concepts covered up to the point each test is given and call for a higher degree of motivation and independence. The midterm and final will require seeking information from outside resources in the form of pricing, equipment performance, or equipment operation. The midterm and final will be issued a week before their due date. The midterm and the final each account for 20% of the total class grade.

01.02

MT. SAN ANTONIO COLLEGE Name:____________________
AIR CONDITIONING AND REFRIGERATION Semester:__________________

AIRC 10 Technical Mathematics in Air conditioning and Refrigeration
Instructor: Darrow Soares Office Hrs:________________

Project Sheet

Project Number	Project	Score	Date	Signature
1	Interpretation of Common Factions			
2	Reading Fractional Values			
3	Reduction of Fractions			
4	Addition of Common Fractions			
5	Addition of Common Fractions			
6	Addition of common Fractions and Mixed Numbers			
7	Multiplication of proper fractions, proper fractions and mixed numbers, and mixed numbers			
8	Multiplication of mixed numbers			
9	Division of mixed numbers, and the division or multiplication of fractions			
10	Multiplication and division of mixed numbers			
11	Expressing Fractions as Decimals			
12	Addition of Decimal Measurements			
13	Subtraction of Decimal Measurements			
14	Multiplication of Decimal Numbers			
15	Multiplication of Decimal Numbers			
16	Division of Decimal Numbers			
17	Surface Measure and Conversion to Equivalent Units			
18	Volume Measure			
19	Volume Measure of a Liquid Receiver			
20	Determining Percentage			
21	Determining Percentage			
22	Solve for Voltage and Current Imbalances			

01.03

MT. SAN ANTONIO COLLEGE Name:________________
AIR CONDITIONING AND REFRIGERATION Semester:________________

AIRC 10 Technical Mathematics in Air conditioning and Refrigeration
Instructor: Darrow Soares Office Hrs:________________

Project Sheet

Project Number	Project	Score	Date	Signature
24	Subtraction of Negative and Positive Quantities			
25	Units and Conversion			
26	Solving for Mass			
27	Solving for Absolute, Gage and Vacuum Pressures			
28	Solve Equations by Addition and Subtraction			
29	Solve Equations by Multiplication and Division			
30	Specific Heat: The Sensible Heat Formula			
31	Latent Heat: The Latent Heat Formula			
32	Latent Heat Formula Application			
33	Solving Algebraic Equations			
34	Report Comparison between the system assigned and a system assigned to a different group			
35	Direct Proportion			
36	Direct Proportion			
37	Inverse Proportion			
38	Solving for Air Volume and Motor Horse-power Requirements			

Objective: After satisfactorily completing this lesson, each student should be able to:

1. Understand the terms and functions of common fractions as they relate to the HVAC industry.
2. Transfer common fraction values to equivalent measurements on tape measures, rulers, and other measuring tools.
3. Reduce proper and improper fractions to their lowest terms.

Information: Basic vocational-technical mathematics by Olivo & Olivo, Unit 6.

Essential Concepts:

1. The denominator of a fraction indicates the equal number of parts into which the the unit is divided.
2. The numerator indicates the number of equal parts of the denominator that is taken.
3. The value of a fraction is not changed when both the numerator and the denominator multiplied or divided by the same number.

Structure:
The instructor will discuss the essential concepts based upon the assigned reading. When no further questions about the essential concepts are observed, the students will complete three in-class projects.

1. Interpretation of Common Fractions
   Circles and squares are divided into 6, 8, 16, 32, or 64 parts. The student must identify, by shading the spaces, the part of the square or circle identified by the fractions. This project can be found at 2.01.

2. Reading Fractional Values
   The student will determine the outside diameter of each sample refrigerant line and reduce the fractional measurment to the nearest 1/16 of an inch.. This project is located at 2.02.

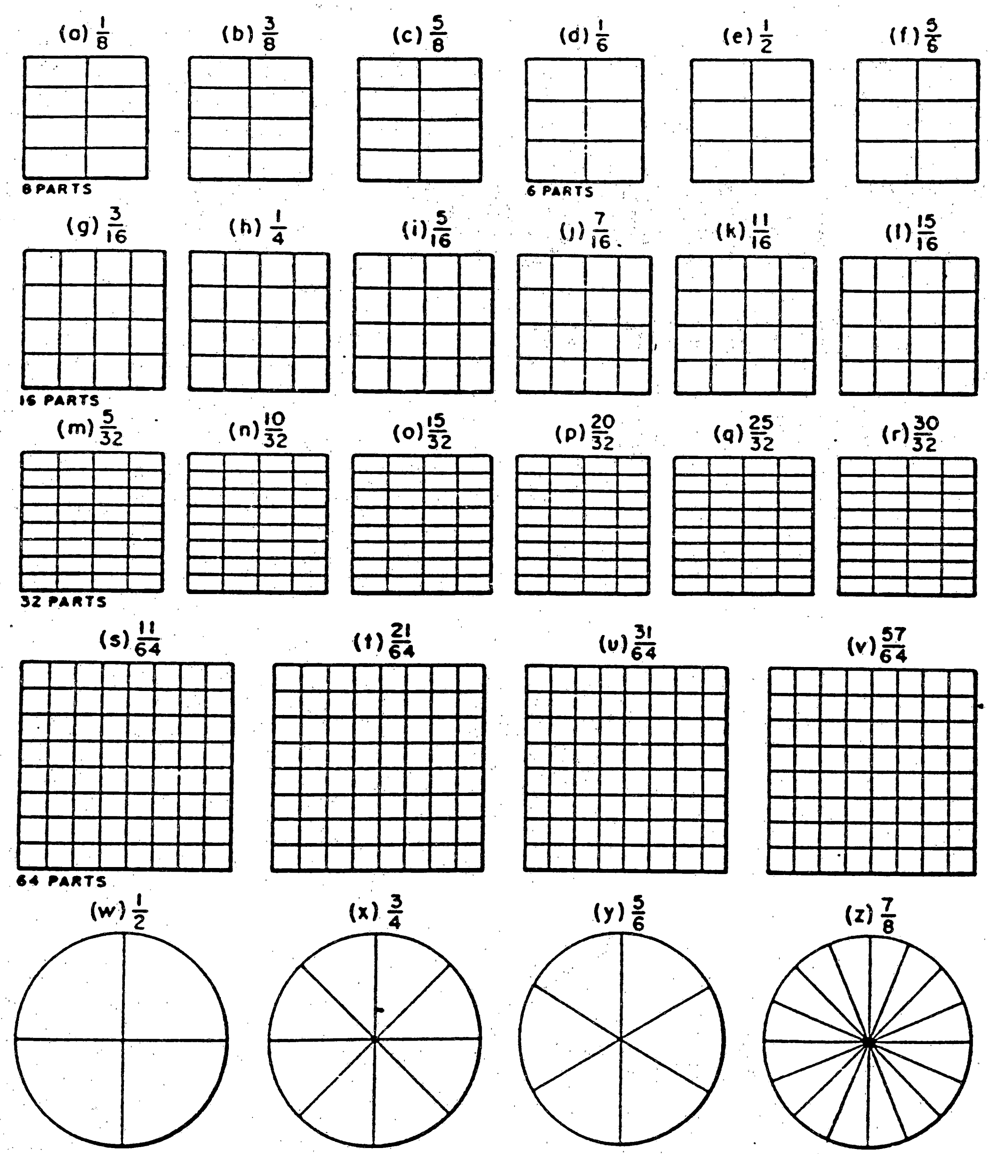
3. Reduction of Fractions
   The student will match each fraction with a sample refrigerant line from project and 2.02 and record it in the space provided. This project is located at 2.03.

Evaluation:
There are six points possible for this activity. Each student completing all three projects will receive full credit for this activity.

Interpretation of Common Fractions

Objective: This project will demonstrate the concept of common fractions

Procedure: The circles and squares below are divided into 6, 8, 16, 32, or 64 parts. Identify, by shading the spaces, the part of the square or circle identified by the fractions



02.02
AIRC 10
Project 2

Name:______
Date:_______

Reading Fractional Values
Reduction of Fractions to Lowest Terms

Objective: This project will allow the student to determine common fractional values to equivalent measurements on steel tapes, rulers, or other measuring tools.

Procedure: Using a tape measure and a sample of copper refrigerant lines and a sample of copper water lines, checked out from the tool crib, the student will record the diameter of each sample line to the nearest 1/16" and record in the space below. The student will reduce each measurement to lowest terms and record to the right of the original measurement.

Record the outside diameter for the refrigerant piping samples.	Record the inside Diameter for the water and plumbing piping samples.
A:_____/_____	I:_____/_____
B:_____/_____	II:_____/_____
C:_____/_____	III:_____/_____
D:_____/_____	IV:_____/_____
E:_____/_____	V:_____/_____
F:_____/_____	VI:_____/_____

02.03
AIRC 10

Name:______

Project 3

Date:_______

Reduction of Fractions to Lowest Terms

Objective: This project will allow the student to reduce fractions to their lowest terms and then apply the measurements to devices commonly used in the HVAC industry.

Procedure: Reduce the following fractions to their lowest terms. Then match each fraction with a sample refrigerant line and record it in the space provided.

22/16______________ 28/32_______________ 9/12______________

15/20______________ 18/16______________ 15/40______________

Reduce the following fractions to their lowest terms. Match each fraction with the sample water piping line and record in the space provided.

6/8 _______________ 5/10_______________ 4/16______________

8/8 ______________ 12/8 _______________ 6/16______________

Objective: After satisfactorily completing this lesson, each student should be able to:
1. Reduce common fractions to lowest common denominators.
2. Add and subtract common fractions.
3. Add and subtract mixed numbers and common fractions.

Information: Basic vocational-technical mathematics by Olivo & Olivo, Unit 7&8.

Essential Concepts:
1. To add or subtract combinations of whole numbers and fractions, the denominators of each fraction must be the same.
2. The smallest number that can be divided by all the denominators is the lowest common denominator.

Structure:
In order to reinforce the essential concepts, the instructor will review the rule for reducing fractions to the lowest common denominator, the rule for adding and subtracting fractions, mixed numbers, and common fractions based on the assigned reading. When no further questions about the essential concepts or rules are observed, the students will complete three in-class projects.

1. Addition of Common Fractions
   Each student will compute the total horsepower of the motors in shelves 3 through 8 in the electrical lab, building 21, room 8. The horsepower rating can be found on nameplate if each motor. This project is located at 3.01.

2. Addition of Common Fractions
   Each lab group will review the rule for connecting capacitors in series and parallel circuits. With the approval of the instructor or T.A. the lab group will connect the capacitors to together to achieve the required microfarad rating based upon the addition of common fractions. This project is located at 3.02.

3. Addition of Common Fractions and Mixed Numbers.
   Each student will check out a tape measure and a sample of copper refrigerant lines. The student will determine the total length of the samples and reduce the answer to lowest terms. This project is located at 3.03.

Evaluation:
There are six points possible for this activity. Each student completing all three projects will receive full credit for this activity.

03.01
AIRC 10
Project 4

Name:______
Date:_______

Addition of Common Fractions

Objective: The purpose of this project is to practice the addition of common ractions based on the addition of fractional horsepower motors.

Procedure: Each student will record the nameplate data of the motors in shelves 3 through 8 in the electrical lab, building 21, room 8. Once the data has been collected and provided in the spaces below, illustrate the motors in a series circuit on a separate sheet of graph paper and show the total horsepower and amperage draw of the circuit.

Motor #1

Frame:_____ Voltage:_______ RLA:________ RPM:______ Hp:_____

Motor #2

Frame:_____ Voltage:_______ RLA:________ RPM:______ Hp:_____

Motor #3

Frame:_____ Voltage:_______ RLA:________ RPM:______ Hp:_____

Motor #4

Frame:_____ Voltage:_______ RLA:________ RPM:______ Hp:_____

Motor #5

Frame:_____ Voltage:_______ RLA:________ RPM:______ Hp:_____

Motor #6

Frame:_____ Voltage:_______ RLA:________ RPM:______ Hp:_____

NOTE: RLA= running load amps. RPM=rotations per minute. Hp=motor horspower

03.02
AIRC 10

Project 5

Name:______
Date:______

Addition of Common Fractions
Capacitors

Objective: The purpose of this project is to practice the addition of common fractions for the purpose of determining the micro farad rating of capacitors electrically connected in series or parallel.

Information: Capacitors can be connected in series or parallel to provide the desired characteristics if the voltage and micro farad (MFD) rating are properly selected. When two capacitors having the same MFD rating are connected in series, the resulting total capacitance will be one half the rated capacitance of a one of the capacitors used alone. That is because the formula for determining capacitance (MFD) when capacitors are connected in series is as follows:

$$1/MFD_t = 1/MFD_1 + 1/MFD_2$$

The voltage rating of capacitors connected in series is equal to the sum of the voltage of the individual capacitors. When capacitors are connected in parallel, the MFD rating is equal to the sum of the individual capacitance. The voltage rating is equal to the lowest voltage rating of the individual capacitors.

Procedure: Each student will be assigned four refrigeration compressors. Based on the model number of each compressor, the student will reference the manufactures performance data to determine the micro farad rating and the voltage rating of the capacitor required for each compressor.

Based on the available capacitors, the student will determine the combination of capacitors-applied in series or parallel- required to achieve the micro farad rating and voltage rating required for the compressors assigned.

With the approval of the instructor, the student connect the capacitors together. When the appropriate connections have been made, the student will apply a capacitance meter to the project and measure the microfarad output of each circuit.

03.03
AIRC 10

Project 6

Name:______

Date:_______

Addition of Common Fractions and Mixed Numbers
Copper Piping and Illustrations

Objective: The purpose of this project is to practice the addition of common fractions and mixed numbers as they apply to illustrations and practical applications.

Procedure: Each student will check out a tape measure and a sample of copper refrigerant lines. The student will determine the total length of the samples and reduce the answer to lowest terms. When the student has completed the initial sample she will trade pipe samples with another student and determine the total length of the new sample set. The student will proceed until all five sample sets have been measured and quantified.

Sample:	**#1**	**#2**	**#3**	**#4**	**#5**
length A					
length B					
length C					
length D					
length E					
length F					
Total Length					

Solve for A through E on the following illustration.

A:__________

B:__________

C:__________

D:__________

Objective: After satisfactorily completing this lesson, the student will be able to:
1. Solve practical problems requiring the multiplication of two or more fractions.
2. Multiply fractions, whole numbers, and mixed numbers.
3. Simplify the multiplication process by the cancellation method.

Information: Basic vocational-technical mathematics by Olivo & Olivo, Unit 9.

Essential Concept:
1. The multiplication of fractions, like the multiplication of whole numbers, is a simplified method of addition.

Structure:
The instructor will discuss the essential concept of the lesson. In order to reinforce the essential concept, the instructor will review the rule for multiplying common fractions, the rule for multiplying a common fraction by a mixed number, and the rule for multiplying fractions, whole numbers, and mixed numbers in any combination. When no further questions about the essential concept or rules are observed, the instructor will discuss the rule of canceling by evenly dividing numerator and denominator. When no further questions about canceling or the previous rules are observed, the students will be assigned one in-class project and one project completed outside of class.

1. Multiplication of proper fractions, proper fractions and mixed numbers, and mixed numbers. Completed in class
   Each student will be given 20 fractions to solve based on the rules discussed. Students completing the assignment early are allowed to work collaboratively with other students requiring additional help. This assignment must be turned by the end of the class session. This project is located at 4.01.

2. Multiplication of mixed numbers.

Evaluation:
There are six points possible for these activities. Students completing both projects will receive full credit. Students who do not come prepared, do not participate, or fail to complete a project will lose three points for each assignment.

04.01
AIRC 10
Project 7

Name:______
Date:_______

Multiplication of Proper Fractions and Mixed Numbers

Objective: The purpose of this project is to practice the multiplication of common fractions and mixed numbers as they apply to written problems and practical applications.

Procedure: Each student will refer to lab project 3.03. Based on the total length of each copper sample, the student will multiply the determined length of each sample by the value given below to solve for a new overall length.

Sample #1 X 12 1/2 = ______	Sample #1 X 7/16 = _____
Sample #2 X 5 1/4 = ______	Sample #2 X 11/32 = _____
Sample #3 X 7 3/4 = ______	Sample #3 X 1/16 = _____
Sample #4 X 11 2/3 = ______	Sample #4 X 21/7 = _____
Sample #5 X 3 1/3 = ______	Sample #5 X 22/8 = _____
Sample #1 X 2 1/8 = ______	Sample #1 X 12/8 = _____
Sample #2 X 4 1/3 = ______	Sample #2 X 4/16 = _____
Sample #3 X 3 1/3 = ______	Sample #3 X 6/17 = _____
Sample #4 X 3 1/8 = ______	Sample #4 X 7/16 = _____
Sample #5 X 4 2/4 = ______	Sample #5 X 2/18 = _____

Objective: After satisfactorily completing this lesson, each student should be able to:
1. Solve practical problems requiring the division of fractions.
2. Solve practical problems requiring the division and multiplication of fractions.

Information: Basic vocational-technical mathematics by Olivo & Olivo, Unit 10.

Essential Concept:
1. Division of fractions is the process of determining how many time one number is contained in another.

Structure:
The instructor will discuss the essential concepts of the lesson. In order to reinforce the essential concepts, the instructor will review the rule for dividing fractions, the rule for dividing a fraction and a whole number, and the rule for dividing mixed numbers. When no further questions about the essential concepts or he rules for dividing fractions are observed, the instructor will discuss the rule for problems requiring the multiplication and division of fractions.

1. Division of mixed numbers, and the division or multiplication of fractions.
   Each student will be given 30 fractions to solve based on the rules discussed. Students completing the assignment early are allowed to work collaboratively with other students requiring additional help. This assignment must be turned in by the end of the class session. This project is located at 5.01.

2. Multiplication and division of mixed numbers.
   Each student will be assigned a package air conditioning unit located in building 21, room three and supplied with product data. From the product data the student will determine the weight of the air conditioning system assigned. By measuring the area the air conditioner occupies (the foot print), the student will determine the number of pounds per foot in the air conditioning system. This project is located at 5.02.

Evaluation:
There are six points possible for these activities. Students completing both projects will receive full credit. Students who do not come prepared, do not participate, or fail to complete a project will lose three points for each assignment.

05.01
AIRC 10
Project 9

Name:______
Date:_______

Multiplication and Division of Mixed Numbers

Objective: The purpose of this project is to allow the student to practice the multiplication and division of fractions as they apply to practical problems in the HVAC industry.

Procedure: Each student will refer to the physical data for AC&R type M and L copper pipe at 5.01a-b. Based upon the physical data, the student will determine the weight of copper pipe based on the diameter and thickness of the type assigned.

When the physical data has been recorded, the student will apply the information to refrigeration installations #16, #17, #18, #19 in building 21, room 3, to address the following problems:

1. Determine the weight of copper used to supply the suction and the liquid line for installation #16.

   Suction line:_____________ Liquid line:_________________

2. Determine the weight of copper used to supply the suction and the liquid line for installation #18.

   Suction line:_____________ Liquid line:_________________

3. Determine the total weight of the copper pipe for units #16, #17, 18#, and #19 suspended from mechanical hangers (channel and all thread).

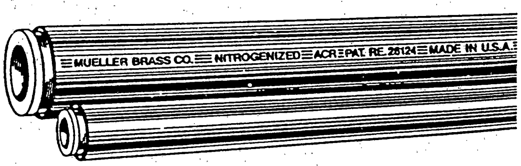
   Total weight:_______________

4. Based on the physical data at 5.01b, what is the weight limit for the hangers installed at installations #16 - #19.

   Weight limit:_______________

Nitrogenized® ACR Copper Tube

Mueller Brass Co.'s patented** cleaning, purging and pressurizing process assures the high level of tube cleanliness established by the conforming to the ASTM B 280 refrigeration industry standard. The tube is sealed with patented* plugs which maintain the standard of cleanliness from the factory to the job site.



Streamline® **COPPER TUBE PRESSURIZED WITH NITROGEN** provides maximum protection against the formation of harmful oxides normally formed during brazing operations. Reduction of these oxides greatly reduces system contamination.

Plugs are reusable. When less than a 20′ length of tube is required for an installation the unused length of tube may be replugged to prevent atmospheric contamination during storage.

Streamline® Nitrogenized ACR seamless copper tube is available in sizes 3/8″ OD thru 3 1/8″ OD. Larger sizes from 3 5/8″ OD thru 6 1/8″ are cleaned and capped.

Mfg. in Accordance with ASTM B88 Type L. Cleaned in Accordance with ASTM B 280. 20-Ft. Lengths Hard Drawn — Cleaned and Capped — Color Coded — Marked "ACR."

Table gives computed allowable stress for annealed copper tube at indicated temperature
SAFE WORKING INTERNAL PRESSURES — ANSI-B31.5-1974

Tube OD	Wall Thickness	Wt. Per Foot	Lengths Per Bundle	150°F PSI	200°F PSI	300°F PSI	400°F PSI
3/8	.030	.126	100	810	720	705	450
1/2	.035	.198	25	675	635	625	395
5/8	.040	.285	25	625	590	580	365
3/4	.042	.362	10	545	515	505	325
7/8	.045	.455	10	495	470	455	290
1 1/8	.050	.655	5	440	410	405	260
1 3/8	.055	.884	5	385	365	355	230
1 5/8	.060	1.14	5	355	340	330	210
2 1/8	.070	1.75	3	315	300	290	185
2 5/8	.080	2.48	2	295	275	275	175
3 1/8	.090	3.33	1	275	260	255	160
3 5/8	.100	4.29	1	270	255	245	155
4 1/8	.110	5.38	1	255	240	235	150
5 1/8	.123	7.61	1	235	220	215	140
6 1/8	.140	10.20	1	215	210	200	125

**U.S. Patent 3,200,984* ***U.S. Patent RE. 28124, Canadian Patents — 723,463 and 751,099*

***Streamline®* Nitrogenized® ACR Copper Tube Is Your Best Investment Against System Contamination.**

Refrigeration Service Tube

Streamline® dehydrated and nitrogen purged sealed copper tube is of a consistent fully annealed temper, bright and thoroughly dried and packaged in individual cartons. Each carton is clearly labeled showing size and length.

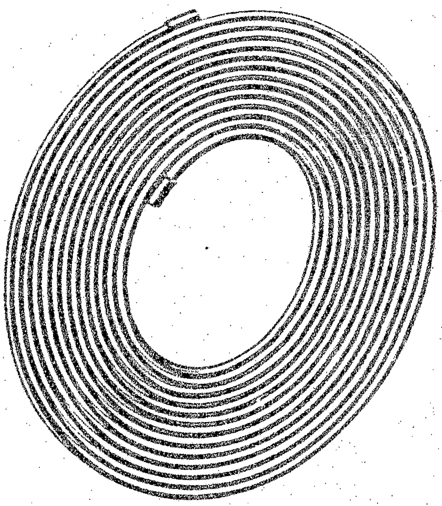
A cleaning and drying process removes moisture and contaminants and the tube is manufactured in accordance with ASTM B 280 and ANSI B9.1 refrigeration industry standards.

For special lengths and sizes not listed please consult your local Mueller Brass Co. representative.

Table gives computed allowable stress for annealed copper tube at indicated temperature

SAFE WORKING INTERNAL PRESSURES — ANSI-B31.5

Tube OD	Wall Thickness	Wt. Per Foot	150°F PSI	250°F PSI	350°F PSI	400°F PSI
⅛	.030	.0347	2660	2450	2080	1570
3/16	.030	.0575	1690	1560	1320	1000
¼	.030	.0804	1230	1130	970	720
5/16	.032	.109	1040	960	820	610
⅜	.032	.134	860	790	670	500
½	.032	.182	630	580	490	370
⅝	.035	.251	540	500	430	320
¾	.035	.305	440	400	350	260
⅞	.045	.455	500	460	390	300
1⅛	.050	.655	430	400	340	250
1⅜	.055	.884	390	360	300	230
1⅝	.060	1.140	370	340	280	220



Weights and Standard Packaging — Individually Cartoned in 50' Coils*

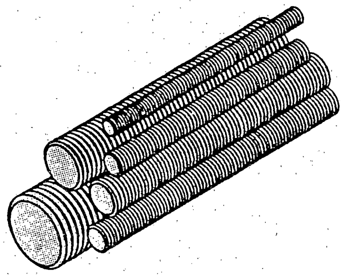
Tube OD	Wt. Per Coil	Coils Per Master Ctn.	Wt. Per Master	Coil Dia.	Ft. Per Master
⅛	1.74	10	17.4	16	500
3/16	2.88	10	28.8	14¾	500
¼	4.02	10	40.2	14¾	500
5/16	5.45	10	54.5	16½	500
⅜	6.70	10	67.0	16½	500
½	9.10	5	45.5	20	250
⅝	12.55	5	62.75	22	250
¾	15.25	3	45.75	25	150
⅞	22.75	—	22.75	27½	50
1⅛	32.75	—	32.75	34½	50
1⅜	44.20	—	44.20	39½	50
1⅝	57.00	—	57.00	39½	50

*100 Foot Coils Also Available

CHANNEL NUTS & HARDWARE

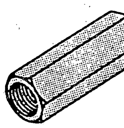
Part No. & Size	Threads Per Inch	*Recommended Load Lbs.	kN	Weight Per 100 Ft. (3048.0 cm) Lbs.	kg
ATR ¼"	20	240	(1.07)	12	(5.44)
ATR 5/16"	18	380	(1.69)	19	(8.62)
ATR ⅜"	16	610	(2.71)	29	(13.15)
ATR ½"	13	1130	(5.02)	53	(24.04)
ATR ⅝"	11	1810	(8.05)	89	(40.37)
ATR ¾"	10	2710	(12.05)	123	(55.79)
ATR ⅞"	9	3770	(16.77)	170	(77.11)
ATR 1"	8	4960	(22.06)	225	(102.06)

*With minimum Safety Factor of 5.
Available in 36" (91.4 cm), 72" (182.9 cm), 120" (304.8 cm), 144" (365.7 cm) lengths.



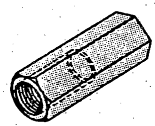
ATR – ALL THREADED ROD

Part No.	Size	Length		Weight Per 100 Lbs.	kg
B655-¼	¼"-20	⅞"	(22.2)	1.9	(.86)
B655-5/16	5/16"-18	⅞"	(22.2)	1.8	(.81)
B655-⅜	⅜"-16	1⅛"	(28.6)	3.6	(1.63)
B655-½	½"-13	1¾"	(44.4)	11.3	(5.12)
B655-⅝	⅝"-11	2⅛"	(54.0)	17.6	(7.98)
B655-¾	¾"-10	2¼"	(57.1)	28.1	(12.74)
B655-⅞	⅞"-9	2½"	(63.5)	57.2	(25.94)
B655-1	1"-8	2¾"	(69.8)	73.7	(33.43)



B655 ROD COUPLING

Part No.	Size	Length		Weight Per 100 Lbs.	kg
B656-⅜ x ¼	⅜"-16 & ¼"-20	1"	(25.4)	3.7	(1.68)
B656-½ x ⅜	½"-13 & ⅜"-16	1¼"	(31.7)	6.6	(2.99)
B656-⅝ x ½	⅝"-11 & ½"-13	1¼"	(31.7)	11.6	(5.26)
B656-¾ x ⅝	¾"-10 & ⅝"-11	1½"	(38.1)	20.6	(9.34)
B656-⅞ x ¾	⅞"-9 & ¾"-10	1¾"	(44.4)	39.4	(17.87)



B656 REDUCER ROD COUPLING

STANDARD FINISH: Electro-Plated

05.02
AIRC 10

Project 10

Name:______

Date:_______

Multiplication and Division of Mixed Numbers

Objective: The purpose of this project is to allow the student to practice the multiplication and division of fractions as they apply to practical problems in the HVAC industry.

Procedure: Each student will be assigned three package air conditioning units located in building 21, room three. Referring to the product data at 5.02a-c, the student will determine the weight of the air conditioning systems assigned. Based on the units weight and the area the system occupies (foot print), the student will determine the number of pounds per square foot of each air conditioning system.

Application: Air conditioning and refrigeration equipment are often located on the roof of a building. Roof trusses and beams supporting this equipment are required to support weight in pounds per square foot.

Unit #1 Unit Model:______________

Unit Weight:_____________

Weight/foot:_____________

Unit #2 Unit Model:______________

Unit Weight:_____________

Weight/foot:_____________

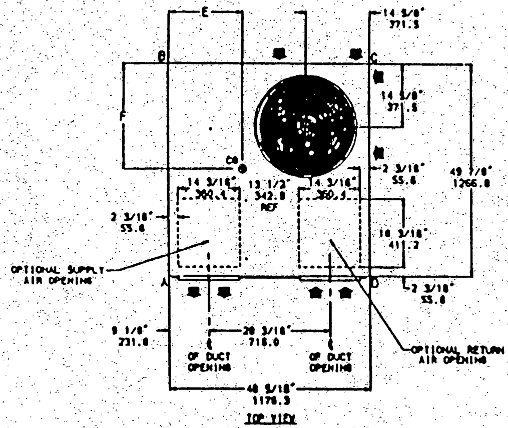
Unit #3 Unit Model:______________

Unit Weight:_____________

Weight/foot:_____________

Dimensions—Small Cabinet Unit

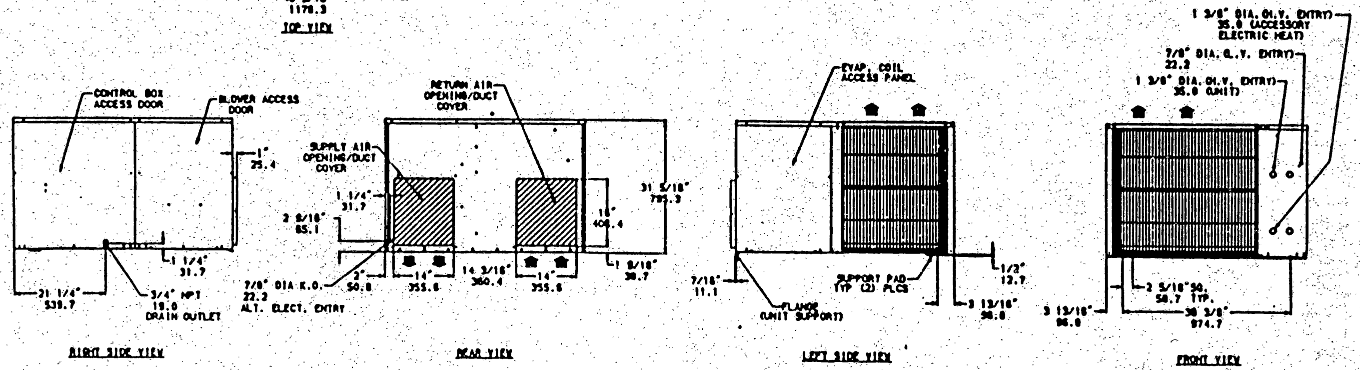
UNIT	UNIT WT.		CORNER WT. LB./KG.				CENTER OF GRAVITY IN./MM	
	LBS	KG.	A	B	C	D	E	F
50NE018	322	146	99/45	100/45	62/28	61/28	17-1/2" / (444.5)	24-1/2" / (622.3)
50NE024	329	149	101/46	106/48	62/28	60/27	17" / (431.8)	24" / (658.6)
50NE030	352	159	87/39	101/46	88/40	76/34	21-1/4" / (615.9)	22-3/4" / (577.8)
50NE036	366	165	100/45	106/48	82/37	78/35	20" / (508.0)	24" / (658.6)
50NE042	371	168	101/46	110/50	84/38	76/34	19-3/4" / (501.6)	23-1/2" / (596.9)



SOME REQUIRED CLEARANCES (INCHES)

UNIT TOP.............................40
DUCT SIDE OF UNIT..............0 MIN.
SIDE OPPOSITE DUCTS..................30
FIRST EIGHTEEN INCHES
OF SUPPLY DUCT.........................1
BLOWER ACCESS PANEL SIDE.......30
CONTROL BOX ACCESS SIDE........30
BOTTOM OF UNIT.........................0

NOTE. PROVISION MUST BE MADE FOR FRESH AMBIENT AIR TO REACH THE OUTDOOR COIL WITHOUT RECIRCULATION OF THE AIR FROM THE OUTDOOR FAN DISCHARGE.

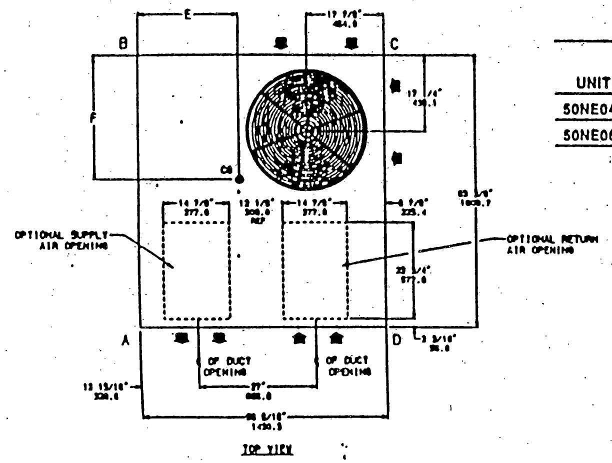


A90015

Dimensional Drawing—Small Cabinet Sizes 018 thru 042

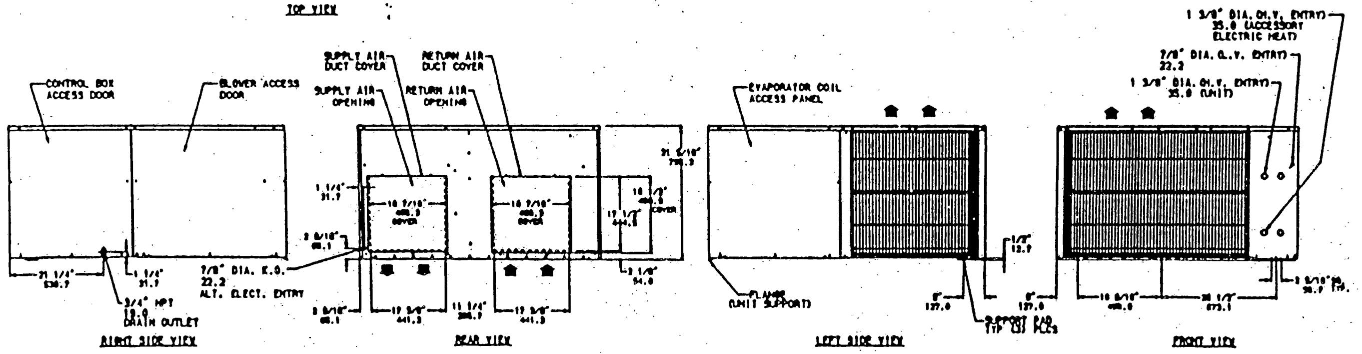
Dimensions—Large Cabinet Unit

UNIT	UNIT WT. LBS.	UNIT WT. KG.	CORNER WT. LB./KG. A	CORNER WT. LB./KG. B	CORNER WT. LB./KG. C	CORNER WT. LB./KG. D	CENTER OF GRAVITY IN./MM E	CENTER OF GRAVITY IN./MM F
50NE048	446	202	119/54	145/66	100/45	82/37	22-3/4" / 577.8	28-1/4" / 717.5
50NE060	480	218	127/58	168/76	105/48	80/36	21-1/2" / 546.1	27-1/2" / 698.5



SOME REQUIRED CLEARANCES (INCHES)

UNIT TOP......48 BLOWER ACCESS PANEL SIDE......30
DUCT SIDE OF UNIT......6 MIN. CONTROL BOX ACCESS SIDE......30
SIDE OPPOSITE DUCTS......30 BOTTOM OF UNIT......0
FIRST EIGHTEEN INCHES OF SUPPLY DUCT......1
NOTE: PROVISION MUST BE MADE FOR FRESH AMBIENT AIR TO REACH THE OUTDOOR COIL WITHOUT RECIRCULATION OF THE AIR FROM THE OUTDOOR FAN DISCHARGE.

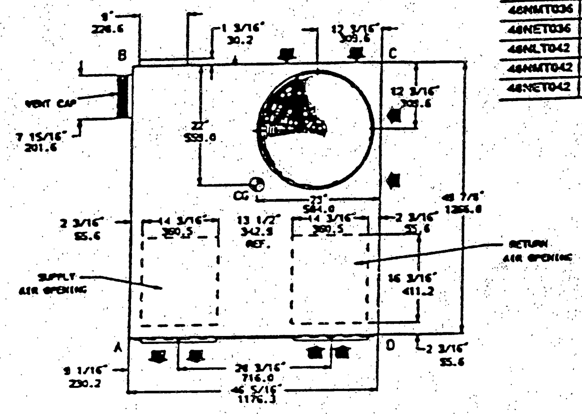


Dimensional Drawing—Large Cabinet Sizes 048 thru 060

Base unit dimensions

SMALL-CABINET UNITS

UNIT	ELECTRICAL CHARACTERISTICS	UNIT WT		CORNER WT (Lb-Kg)			
		Lb	Kg	A	B	C	D
48NLT018	208/230-1-60	450	204	99/ 45	126/57	126/57	99/45
48NLT024	208/230-1-60	454	206	100/45	127/58	127/58	100/45
48NHT024	208/230-1-60	460	210	101/46	129/59	129/58	101/46
48NLT030	208/230-1-60	470	214	103/47	132/60	132/60	103/47
48NMT030	208/230-1-60	476	216	105/48	133/60	133/60	105/48
48NHT030	208/230-1-60	480	218	106/48	134/61	134/61	106/48
48NLT036	208/230-1-60, 208/230-3-60, 460-3-60	486	222	107/49	136/62	136/62	107/49
48NMT036	208/230-1-60, 208/230-3-60, 460-3-60	490	222	108/49	137/62	137/62	108/49
48NET036	208/230-1-60, 208/230-3-60, 460-3-60	490	222	108/49	137/62	137/62	108/49
48NLT042	208/230-1-60, 208/230-3-60, 460-3-60	496	224	109/49	139/63	139/63	109/49
48NMT042	208/230-1-60, 208/230-3-60, 460-3-60	500	228	110/50	140/64	140/64	110/50
48NET042	208/230-1-60, 208/230-3-60, 460-3-60	500	228	110/50	140/64	140/64	110/50



TOP VIEW

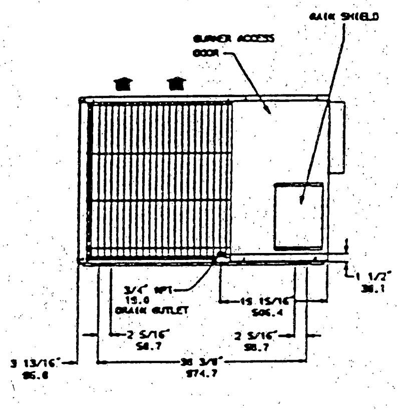
REQUIRED CLEARANCES TO COMBUSTIBLE MATERIALS — in. (mm)

Maximum Extension of Overhang 48 (1219.2)
Unit Top 36 (914.4)
Duct Side of Unit . . . . . 6 min. (152.4 min)
Side Opposite Ducts 30 (762.0)
Bottom of Unit 0

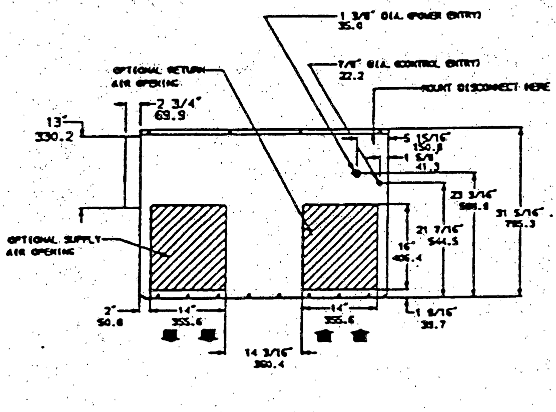
REQUIRED CLEARANCES FOR SERVICING — in. (mm)

Blower Access Panel Side 30 (762.0)
Control Box Access Side 30 (762.0)

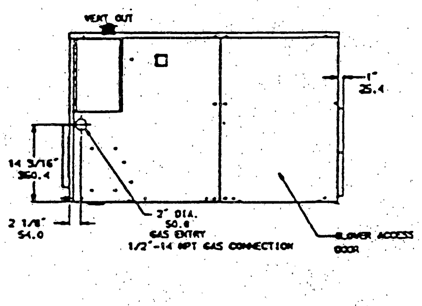
NOTE: Clearances must be maintained to prevent recirculation of air from condenser fan discharge.



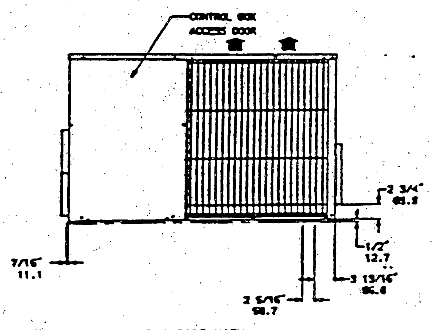
FRONT VIEW



REAR VIEW



RIGHT SIDE VIEW



LEFT SIDE VIEW

Objective: After Satisfactorily completing this lesson, each student should be able to:
1. Understand how fractional measurements are written in the decimal system.
2. Round off decimals
3. Add and subtract decimals in general applications and in practical measurement problems.

Information: Basic vocational-technical mathematics by Olivo & Olivo, Unit 12.

Essential Concepts:
1. A decimal number is a fraction with a denominator of 10, 100, 1000, or any multiple of 10.
2. To add or subtract fractions, the given numbers are written so the decimals are aligned in a vertical column and then added or subtracted the same as regular whole numbers

Structure:
The instructor will review the rule for expressing decimal values, the rule for rounding off decimals, and the rule for adding and subtracting decimals based on the assigned reading. When no further questions about the essential concepts or rules are observed, the students will complete three in-class projects.

1. Expressing Fractions as Decimals
The student will determine the outside diameter of each sample and convert the answer to a decimal equivalent. This project is located at 6.01.

2. Addition of Decimal Measurements
Based on the refrigerant line samples, the student will determine the total length of samples combined and convert to a decimal equivalent. This project is located at 6.02.

3. Subtraction of Decimal Measurements
The wire diameter for wire gage sizes 10 through 16 is given in the National Electrical Code section 70-830. Based on the NEC, each student will determine the difference in diameter between given wire gage sizes. This project is located at 6.03

Evaluation:
There are five points possible for this activity. Each student completing all three projects will receive full credit for this activity.

06.01
AIRC 10

Name:______

Date:_______

Project 11

Expressing Fractions as Decimals

Objective: The purpose of this project is to practice converting fractional measurements into decimal measurements.

Procedure: Each student will check out a tape measure and a sample of copper refrigerant lines. The student will determine the outside diameter of each sample refrigerant line and convert the answer to a decimal equivalent. When the student has completed the initial sample she will trade pipe samples with another student and determine the decimal equivalent of the new sample set. The student will proceed until all five sample sets have been measured and quantified.

Sample:	#1	#2	#3	#4	#5
ODD: A.	___:___	___:___	___:___	___:___	___:___
O.D: B.	___:___	___:___	___:___	___:___	___:___
O.D: C.	___:___	___:___	___:___	___:___	___:___
O.D: D.	___:___	___:___	___:___	___:___	___:___
O.D: E.	___:___	___:___	___:___	___:___	___:___

Sample:	#1	#2	#3	#4	#5
I.D: I.	___:___	___:___	___:___	___:___	___:___
I.D: II.	___:___	___:___	___:___	___:___	___:___
I.D: III.	___:___	___:___	___:___	___:___	___:___
I.D: IV.	___:___	___:___	___:___	___:___	___:___
I.D: V.	___:___	___:___	___:___	___:___	___:___

O.D. = outside diameter of pipe. I.D. = inside diameter of pipe

06.02
AIRC 10
Project 12

Name:______
Date:_______

Expressing Fractions as Decimals

Objective: The purpose of this project is to practice converting fractional measurements into decimal measurements.

Procedure: Each student will check out a tape measure and a sample of copper refrigerant lines. The student will determine the total length of each sample set as a mixed number and convert the mixed number to a decimal equivalent.

Sample:	#1	#2	#3	#4	#5
length A.	___/___	___/___	___/___	___/___	___/___
length B.	___/___	___/___	___/___	___/___	___/___
length C.	___/___	___/___	___/___	___/___	___/___
length D.	___/___	___/___	___/___	___/___	___/___
length E.	___/___	___/___	___/___	___/___	___/___
length F.	___/___	___/___	___/___	___/___	___/___
Total Length	___/___	___/___	___/___	___/___	___/___

06.03
AIRC 10
Project 13

Name:______
Date:_______

Subtraction of Decimal Measurements for Electrical Wire Gages

Objective: The purpose of this project is to practice the addition and subtraction of decimal numbers as they apply to electrical conductors used in the HVAC industry.

Information: Wire gages are based on the cross-sectional area of the wire and are measured in mils, circular mils (CM), or square mils (SM). The cross sectional area of a conductor is the area of the end of a conductor when cut at a right angle to its length. A circular mil of area is equal to the area of a circle one mil in diameter. A square mil of area is equal to the area of a square whose measurements are one mil on each side. A mil is a unit of wire measurement equal to one-thousandth of an inch.

Procedure: Based upon the National Electrical Code (NEC) sample found at 6.03a-b, each student will determine the difference in diameter, Resistance in ohms per 1000 ft, and ampacity between the wire gage sizes given below.

Wire Size AWG	**Diff. Dia, in.**	**Diff. Ohms/M**	**Diff/ Amp.**
10 & 14			
8 & 10			
10 & 12			
0 & 2			
6 & 8			

TABLE 4-2 (NEC TABLE 310-12) ALLOWABLE AMPACITIES OF INSULATED COPPER CONDUCTORS

Not More than Three Conductors in Raceway or Cable or Direct Burial (Based on Ambient Temperature of 30° C 86° F)

Size	Temperature Rating of Conductor. See Table 310-2a							
AWG MCM	60°C (140°F)	75°C (167°F)	85°C (185°F)	90°C (194°F)	110°C (230°F)	125°C (257°F)	200°C (392°F)	250°C (482°F)
	TYPES RUW (14-2), T, TW	TYPES RH, RHW, RUH (14-2), THW, THWN, XHHW	TYPES V, MI	TYPES TA, TBS, SA, AVB, SIS, FEP, FEPB, RHH, THHN, XHHW*	TYPES AVA, AVL	TYPES AI (14-8), AIA	TYPES A (14-8), AA FEP† FEBP†	TYPE TFE (Nickel or nickel-coated copper only)
14	15	15	25	25‡	30	30	30	40
12	20	20	30	30‡	35	40	40	55
10	30	30	40	40‡	45	50	55	75
8	40	45	50	50	60	65	70	95
6	55	65	70	70	80	85	95	120
4§	70	85	90	90	105	115	120	145
3§	80	100	105	105	120	130	145	170
2§	95	115	120	120	135	145	165	195
1§	110	130	140	140	160	170	190	220
0§	125	150	155	155	190	200	225	250
00§	145	175	185	185	215	230	250	280
000	165	200	210	210	245	265	285	315
0000	195	230	235	235	275	310	340	370
250	215	255	270	270	315	335		
300	240	285	300	300	345	380		
350	260	310	325	325	390	420		
400	280	335	360	360	420	450		
500	320	380	405	405	470	500		
600	355	420	455	455	525	545		
700	385	460	490	490	560	600		
750	400	475	500	500	580	620		
800	410	490	515	515	600	640		
900	435	520	555	555				
1000	455	545	585	585	680	730		
1250	495	590	645	645				
1500	520	625	700	700	785			
1750	545	650	735	735				
2000	560	665	775	775	840			

* For dry locations only. See Table 310-2*a*.

These ampacities relate only to conductors described in Table 310-2(a).

† Special use only. See Table 310-2*a*.

‡ The ampacities for Types FEP, FEPB, RHH, THHN, and XHHW conductors for sizes AWG 14, 12, and 10 shall be the same as designated for 75°C conductors in this Table.

For ambient temperatures over 30°C, see Correction Factors, Note 13.

§ For three-wire, single-phase residential services, the allowable ampacity of RH, RHH, RHW, THW and XHHW copper conductors shall be for sizes No 4-100 Amp., No. 3-110 Amp., No. 2-125 Amp., No. 1-150 Amp., No. 1/0-175 Amp., and No. 2/0-200 Amp.

TABLE 4-1. DATA ON ROUND ANNEALED COPPER WIRE

Wire Size, AWG	Diam, in.	CM	SM	Ohms per M ft 68°F	Ft. per lb.
4/0	0.4600	211600	166200	0.04901	1.561
3/0	0.4096	167800	131800	0.06182	1.969
2/0	0.3648	133100	104500	0.07793	2.482
1/0	0.3249	105600	82910	0.09825	3.130
1	0.2893	83690	65730	0.1239	3.947
2	0.2576	66360	52120	0.1563	4.978
3	0.2294	52620	41330	0.1971	6.278
4	0.2043	41740	32780	0.2485	7.915
5	0.1819	33090	25990	0.3134	9.984
6	0.1620	26240	20610	0.3952	12.59
7	0.1443	20820	16350	0.4981	15.87
8	0.1285	16510	12960	0.6281	20.01
9	0.1144	13090	10280	0.7925	25.24
10	0.1019	10380	8155	0.9988	31.82
11	0.0907	8230	6460	1.26	40.2
12	0.0808	6530	5130	1.59	50.6
13	0.0720	5180	4070	2.00	63.7
14	0.0641	4110	3230	2.52	80.4
15	0.0571	3260	2560	3.18	101
16	0.0508	2580	2030	4.02	128
17	0.0453	2050	1610	5.05	161
18	0.0403	1620	1280	6.39	203
19	0.0359	1290	1010	8.05	256
20	0.0320	1020	804	10.1	323
21	0.0285	812	638	12.8	407
22	0.0253	640	503	16.2	516
23	0.0226	511	401	20.3	647
24	0.0201	404	317	25.7	818
25	0.0179	320	252	32.4	1030
26	0.0159	253	199	41.0	1310
27	0.0142	202	158	51.4	1640
28	0.0126	159	125	65.3	2080
29	0.0113	128	100	81.2	2590
30	0.0100	100	78.5	104	3300
31	0.0089	79.2	62.2	131	4170
32	0.0080	64.0	50.3	162	5160
33	0.0071	50.4	39.6	206	6550
34	0.0063	39.7	31.2	261	8320
35	0.0056	31.4	24.6	331	10500
36	0.0050	25.0	19.6	415	13200
37	0.0045	20.2	15.9	512	16300
38	0.0040	16.0	12.6	648	20600
39	0.0035	12.2	9.62	847	27000

Objective: After satisfactorily completing this lesson, each student should be able to:
1. Solve practical measurement problems involving the multiplication and division of decimals.
2. Express fractions and mixed numbers as decimals.

Information: Basic vocational-technical mathematics by Olivo & Olivo, Unit 15&16.

Essential Concepts:
1. The multiplication of decimals, like the multiplication of whole numbers, is a simplified method of addition.
2. Division of decimals is the process of determining how many times one number is contained in another.
3. Decimals are the result of dividing the numerator of a fraction by its denominator.

Structure
The instructor will discuss the essential concepts of the lesson. In order to reinforce the essential concepts, the instructor will review the rule for multiplying decimals, the rule for dividing decimals, the rule for expressing fractions as decimals, and the rule for changing decimal to percent. When no further questions about the essential concepts or rules are observed, the students will complete three in-class projects.

1. Multiplication of decimal numbers.
   Based upon a list of material assigned by the instructor, the student will compute the total cost of the material including sales tax. This project is located at 7.01.

2. Multiplication of decimal numbers
   Based upon the Dupont manual, Thermodynamic Properties of Freon 22 the student will determine the density of R-22 refrigerant at a given sensible temperature. The student will determine the weight of refrigerant required to fully charge receivers with the various volumes. This project is located at 7.02.

3. Division of decimal numbers.
   Each student will determine the capacity of refirgeration evaporators.This project is located at 7.03.

Evaluation:
There are six points possible for this activity. Students who do not come prepared, or fail to complete a project will loose credit for each criteria they fail to meet.

07.01
AIRC 10
Project 14

Name:______
Date:_______

Multiplication of Decimal Numbers

Objective: The purpose of this project is to practice multiplying decimal numbers as they apply to the purchase of equipment and materials used in the HVAC industry.

Procedure: Each student will be assigned a catalogue from an air conditioning and refrigeration supplier common to the sample found at 07.01a. Based upon the list of material and equipment listed below, the student will compute the total cost of refrigeration material including sales tax.

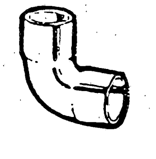
Quantity	Unit	Description	Unit Price	Extension
12	ea.	7/8 90 short radios ells C X C		
3	ea.	7/8 short radius street ells FTG X C		
5	ea.	1 1/8 90 short radius street ells FTG X C		
6	ea.	3/8 90 long radius ells		
6	ea.	3/8 90 short radius ells		
7	ea.	1 3/8 90 long radius ells		
2	ea.	2 1/8 90 long radius ells		
		Sub Total		
		Sales Tax		
		Total		

Pipe & Fittings
WROT COPPER SOLDER FITTINGS

NIBCO

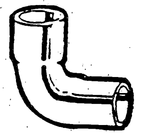
Due to rapidly fluctuating market prices for copper, contact your local Johnstone for current prices.

AC/REFRIGERATION FITTINGS MEASURED BY OD.
PLUMBING/HYDRONIC FITTINGS MEASURED BY NOMINAL.



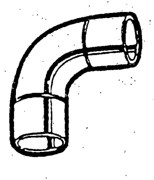
90° CLOSE RUFF ELBOWS C x C

OD Size	Nominal Size	Order Stock #	Dealer Price Each	Dealer Price Lot
5/8"	1/2"	R54-070	$ .36	$ .28/ 50
3/4"	5/8"	R54-071	$1.68	$1.51/ 50
7/8"	3/4"	R54-072	$ .66	$ .59/ 25
1-1/8"	1"	R54-073	$1.53	$1.38/ 10



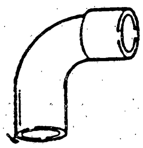
90° CLOSE RUFF STREET ELBOWS FTG x C

OD Size	Nominal Size	Order Stock #	Dealer Price Each	Dealer Price Lot
5/8"	1/2"	R54-074	$ .48	$ .39/ 50
3/4"	5/8"	R54-075	$1.75	$1.58/ 50
7/8"	3/4"	R54-076	$ .96	$ .86/ 25
1-1/8"	1"	R54-077	$2.32	$2.09/ 10



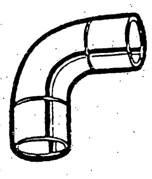
90° SHORT RADIUS ELBOWS C x C

OD Size	Nominal Size	Order Stock #	Dealer Price Each	Dealer Price Lot
1/4"	1/8"	R53-292	$ .83	$ .75/ 50
3/8"	1/4"	R53-294	$ .83	$ .75/ 50
1/2"	3/8"	R53-295	$ .83	$ .75/ 50
5/8"	1/2"	R53-289	$ .84	$ .76/100
3/4"	5/8"	R53-290	$ 1.68	$1.51/ 50
7/8"	3/4"	R53-606	$ 1.49	$1.34/ 50
1-1/8"	1"	R53-689	$ 2.02	$1.82/ 25
1-3/8"	1-1/4"	R53-682	$ 2.32	$2.09/ 25
1-5/8"	1-1/2"	R53-914	$ 3.63	$3.27/ 10
2-1/8"	2"	R53-915	$ 6.61	$5.95/ 5
2-5/8"	2-1/2"	R54-395	$12.56	—
3-1/8"	3"	R54-396	$17.62	—



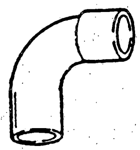
90° SHORT RADIUS STREET ELBOWS FTG x C

OD Size	Nominal Size	Order Stock #	Dealer Price Each	Dealer Price Lot
1/4"	1/8"	R53-704	$ 1.54	$1.39/ 50
3/8"	1/4"	R53-691	$ 1.54	—
1/2"	3/8"	R53-300	$ .89	$ .80/ 50
5/8"	1/2"	R53-296	$ 1.05	$ .95/ 50
3/4"	5/8"	R53-297	$ 1.75	$1.58/ 25
7/8"	3/4"	R53-608	$ 1.72	$1.55/ 25
1-1/8"	1"	R53-692	$ 2.32	$2.09/ 10
1-3/8"	1-1/4"	R53-693	$ 3.57	$3.21/ 10
1-5/8"	1-1/2"	R53-918	$ 4.63	$4.17/ 5
2-1/8"	2"	R53-919	$10.09	$9.08/ 5



90° LONG RADIUS ELBOWS C x C

OD Size	Nominal Size	Order Stock #	Dealer Price Each	Dealer Price Lot
3/16"	—	R53-291	$ 1.46	$ 1.31/ 50
1/4"	1/8"	R53-683	$ 1.31	$ 1.18/ 10
5/16"	—	R53-293	$ 1.46	$ 1.31/ 50
3/8"	1/4"	R53-684	$ 1.31	$ 1.18/ 50
1/2"	3/8"	R53-685	$ 1.59	$ 1.43/ 50
5/8"	1/2"	R53-686	$ 1.40	$ 1.26/ 50
3/4"	5/8"	R53-687	$ 1.52	$ 1.37/ 50
7/8"	3/4"	R53-688	$ 1.92	$ 1.73/ 25
1-1/8"	1"	R53-668	$ 2.78	$ 2.50/ 10
1-3/8"	1-1/4"	R53-690	$ 4.42	$ 3.98/ 10
1-5/8"	1-1/2"	R53-916	$ 5.94	$ 5.35/ 5
2-1/8"	2"	R53-917	$14.02	$12.62/ 5
2-5/8"	2-1/2"	R54-397	$24.26	—
3-1/8"	3"	R54-398	$34.14	—



90° LONG RADIUS STREET ELBOWS FTG x C

OD Size	Nominal Size	Order Stock #	Dealer Price Each	Dealer Price Lot
3/8"	1/4"	R53-964	$ 1.52	$ 1.37/ 50
1/2"	3/8"	R53-965	$ 2.87	$ 2.58/100
5/8"	1/2"	R53-966	$ 2.06	$ 1.85/ 50
3/4"	5/8"	R53-967	$ 2.41	$ 2.17/ 25
7/8"	3/4"	R53-968	$ 2.45	$ 2.21/ 25
1-1/8"	1"	R53-969	$ 3.96	$ 3.56/ 10
1-3/8"	1-1/4"	R53-970	$ 5.88	$ 5.29/ 10
1-5/8"	1-1/2"	R53-971	$ 7.99	$ 7.19/ 5
2-1/8"	2"	R53-972	$13.05	$11.75/ 5

07.02
AIRC 10
Project 15

Name:______
Date:_______

Multiplication of Decimal Numbers

Objective: The purpose of this project is to practice the multiplication of decimal numbers as the process applies to the physical characteristics of refrigerants used in the HVAC industry

Information: On most refrigeration equipment, the condenser is not large enough to store the refrigerant charge during pump-down or low load conditions. As a result, a liquid receiver is installed between the condenser and the metering device to receive the refrigerant during these conditions. The receiver should be sized so that under any condition, it is never filled more than 80% of capacity. This is to allow room for expansion from sensible temperature changes.

Procedure: Based upon the sample Dupont Manual, Thermodynamic Properties of Freon 22 found at 7.02a-b, each student will determine the density of R-22 refrigerant at a given sensible temperature. From this information, the student will determine the weight of refrigerant required to fully charge a liquid receiver on a specified refrigeration system given the volume of the receiver.

R-22

Temp ^{0}F	**PSIG**	**Density**	**Receiver Volume cu. ft.**	**Refrigerant Weight in lb.**
40			0.70	
64			6.28	
68			0.70	
78			6.28	
68			0.32	
72			0.53	

PHYSICAL PROPERTIES

Chemical Formula:	$CHClF_2$
Molecular Weight:	86.476
Boiling Point at one atmosphere, °F	−41.36
Freezing Point, °F	−256
Critical Temperature, °F	204.81
Critical Pressure, psia	721.906
Critical Density, lb/cu ft	32.76
Critical Volume, cu ft/lb	0.030525
Refractive Index (n_D), 70°F	
Liquid	1.259
Vapor (one atmosphere)	1.00073
Dielectric Constant:	
Liquid at 75°F	6.11
Vapor (0.5 atmosphere) at 78°F	1.0035
Relative Dielectric Strength (N_2 = 1) at 1 atmosphere with 0.1-inch gap and 0.75-inch-sphere-to-plane gap at 77°F.	1.3

Thermal Conductivity, k, in Btu/(hr)(ft)(°F)

t °F	k
Liquid	
−40	0.0792
0	0.0698
40	0.0605
120	0.0417
Vapor (one atmosphere)	
−40	0.0050
0	0.0056
40	0.0061
120	0.0072

Viscosity, η, in Centipoises:

t °F	η
Liquid	
−40	0.349
0	0.298
40	0.261
120	0.211
Vapor (one atmosphere)	
−40	0.0100
0	0.0111
40	0.0121
120	0.0140

Surface Tension, γ, in dynes/cm:

t °F	γ
−40	18.5
0	14.9
40	11.4
120	4.9

Solubility of Water in the Liquid:

t °F	ppm
−100	19
−40	120
40	690
100	1800

Flammability:

Nonflammable and nonexplosive at ordinary temperatures. May form weakly combustible mixtures with air at very high temperatures.

Toxicity:

Very low toxicity—rated in Group 5a by the Underwriters' Laboratories in their report MH No. 3134.

UNITS AND FACTORS

t = temperature in °F
T = temperature in °R = °F + 459.69
psia = pressure in lb/sq in absolute
psig = pressure in lb/sq in gage
p = pressure of vapor in psia
p_{sat} = pressure of saturated vapor in psia
v_f = volume of the saturated liquid in cu ft/lb
v_g = volume of the saturated vapor in cu ft/lb
V = volume of the superheated vapor in cu ft/lb
$d_f = 1/v_f$ = density of the saturated liquid in lb/cu ft
$d_g = 1/v_g$ = density of the saturated vapor in lb/cu ft
h_f = enthalpy of the saturated liquid in Btu/lb
h_{fg} = enthalpy of vaporization in Btu/lb
h_g = enthalpy of the saturated vapor in Btu/lb
H = enthalpy of the superheated vapor in Btu/lb
s_f = entropy of the saturated liquid in Btu/(lb.)(°R)
s_g = entropy of the saturated vapor in Btu/(lb)(°R)
S = entropy of the superheated vapor in Btu/(lb)(°R)
c_f = heat capacity of the saturated liquid in Btu/(lb)(°F)
c_v^o = heat capacity of the vapor at constant volume in Btu/(lb)(°F) at zero pressure
c_p = heat capacity of the vapor at constant pressure in Btu/(lb)(°F)
c_v = heat capacity of the vapor at constant volume in Btu/(lb)(°F)
k = thermal conductivity in Btu/(hr) (ft) (°F)
η = viscosity in centipoises
γ = surface tension in dynes/cm
n_D = refractive index
e = base of natural logarithms = 2.718281828

The gas constant, R = 10.7315 (psia) (cu ft)/(°R) (lb mol)
Heat units (Btu/lb) = work units (psia) (cu ft/lb) × 0.185053
One atmosphere = 14.696 psia = 29.9212 inches of mercury

07.02c

TABLE I "FREON" 22 SATURATION PROPERTIES—TEMPERATURE TABLE

TEMP.	PRESSURE		VOLUME cu ft/lb		DENSITY lb/cu ft		ENTHALPY Btu/lb			ENTROPY Btu/(lb)(°R)		TEMP.
°F	PSIA	PSIG	LIQUID v_f	VAPOR v_g	LIQUID $1/v_f$	VAPOR $1/v_g$	LIQUID h_f	LATENT h_{fg}	VAPOR h_g	LIQUID s_f	VAPOR s_g	°F
65	125.93	111.23	0.013136	0.43663	76.126	2.2903	28.638	81.432	110.070	0.06021	0.21541	65
66	127.92	113.22	0.013159	0.42981	75.996	2.3266	28.932	81.208	110.140	0.06076	0.21524	66
67	129.94	115.24	0.013181	0.42311	75.865	2.3635	29.228	80.982	110.209	0.06131	0.21507	67
68	131.97	117.28	0.013204	0.41653	75.733	2.4008	29.523	80.755	110.278	0.06186	0.21490	68
69	134.04	119.34	0.013227	0.41007	75.601	2.4386	29.819	80.527	110.346	0.06241	0.21473	69
70	136.12	121.43	0.013251	0.40373	75.469	2.4769	30.116	80.298	110.414	0.06296	0.21456	70
71	138.23	123.54	0.013274	0.39751	75.336	2.5157	30.413	80.068	110.480	0.06351	0.21439	71
72	140.37	125.67	0.013297	0.39139	75.202	2.5550	30.710	79.836	110.547	0.06406	0.21422	72
73	142.52	127.83	0.013321	0.38539	75.068	2.5948	31.008	79.604	110.612	0.06461	0.21405	73
74	144.71	130.01	0.013345	0.37949	74.934	2.6351	31.307	79.370	110.677	0.06516	0.21388	74
75	146.91	132.22	0.013369	0.37369	74.799	2.6760	31.606	79.135	110.741	0.06571	0.21372	75
76	149.15	134.45	0.013393	0.36800	74.664	2.7174	31.906	78.899	110.805	0.06626	0.21355	76
77	151.40	136.71	0.013418	0.36241	74.528	2.7593	32.206	78.662	110.868	0.06681	0.21338	77
78	153.69	138.99	0.013442	0.35691	74.391	2.8018	32.506	78.423	110.930	0.06736	0.21321	78
79	155.99	141.30	0.013467	0.35151	74.254	2.8449	32.808	78.184	110.991	0.06791	0.21305	79
80	158.33	143.63	0.013492	0.34621	74.116	2.8885	33.109	77.943	111.052	0.06846	0.21288	80
81	160.68	145.99	0.013518	0.34099	73.978	2.9326	33.412	77.701	111.112	0.06901	0.21271	81
82	163.07	148.37	0.013543	0.33587	73.839	2.9774	33.714	77.457	111.171	0.06956	0.21255	82
83	165.48	150.78	0.013569	0.33083	73.700	3.0227	34.018	77.212	111.230	0.07011	0.21238	83
84	167.92	153.22	0.013594	0.32588	73.560	3.0686	34.322	76.966	111.288	0.07065	0.21222	84
85	170.38	155.68	0.013620	0.32101	73.420	3.1151	34.626	76.719	111.345	0.07120	0.21205	85
86	172.87	158.17	0.013647	0.31623	73.278	3.1622	34.931	76.470	111.401	0.07175	0.21188	86
87	175.38	160.69	0.013673	0.31153	73.137	3.2100	35.237	76.220	111.457	0.07230	0.21172	87
88	177.93	163.23	0.013700	0.30690	72.994	3.2583	35.543	75.968	111.512	0.07285	0.21155	88
89	180.50	165.80	0.013727	0.30236	72.851	3.3073	35.850	75.716	111.566	0.07339	0.21139	89
90	183.09	168.40	0.013754	0.29789	72.708	3.3570	36.158	75.461	111.619	0.07394	0.21122	90
91	185.72	171.02	0.013781	0.29349	72.564	3.4073	36.466	75.206	111.671	0.07449	0.21106	91
92	188.37	173.67	0.013809	0.28917	72.419	3.4582	36.774	74.949	111.723	0.07504	0.21089	92
93	191.05	176.35	0.013836	0.28491	72.273	3.5098	37.084	74.690	111.774	0.07559	0.21072	93
94	193.76	179.06	0.013864	0.28073	72.127	3.5621	37.394	74.430	111.824	0.07613	0.21056	94
95	196.50	181.80	0.013893	0.27662	71.980	3.6151	37.704	74.168	111.873	0.07668	0.21039	95
96	199.26	184.56	0.013921	0.27257	71.833	3.6688	38.016	73.905	111.921	0.07723	0.21023	96
97	202.05	187.36	0.013950	0.26859	71.685	3.7232	38.328	73.641	111.968	0.07778	0.21006	97
98	204.87	190.18	0.013979	0.26467	71.536	3.7783	38.640	73.375	112.015	0.07832	0.20989	98
99	207.72	193.03	0.014008	0.26081	71.386	3.8341	33.953	73.107	112.060	0.07887	0.20973	99
100	210.60	195.91	0.014038	0.25702	71.236	3.8907	39.267	72.838	112.105	0.07942	0.20956	100
101	213.51	198.82	0.014068	0.25329	71.084	3.9481	39.582	72.567	112.149	0.07997	0.20939	101
102	216.45	201.76	0.014098	0.24952	70.933	4.0062	39.897	72.294	112.192	0.08052	0.20923	102
103	219.42	204.72	0.014128	0.24600	70.780	4.0651	40.213	72.020	112.233	0.08107	0.20906	103
104	222.42	207.72	0.014159	0.24244	70.626	4.1247	40.530	71.744	112.274	0.08161	0.20889	104
105	225.45	210.75	0.014190	0.23894	70.472	4.1852	40.847	71.467	112.314	0.08216	0.20872	105
106	228.50	213.81	0.014221	0.23549	70.317	4.2465	41.166	71.187	112.353	0.08271	0.20855	106
107	231.59	216.90	0.014253	0.23209	70.161	4.3086	41.485	70.906	112.391	0.08326	0.20838	107
108	234.71	220.02	0.014285	0.22875	70.005	4.3715	41.804	70.623	112.427	0.08381	0.20821	108
109	237.86	223.17	0.014317	0.22546	69.847	4.4354	42.125	70.338	112.463	0.08436	0.20804	109
110	241.04	226.35	0.014350	0.22222	69.689	4.5000	42.446	70.052	112.498	0.08491	0.20787	110
111	244.25	229.56	0.014382	0.21903	69.529	4.5656	42.768	69.763	112.531	0.08546	0.20770	111
112	247.50	232.80	0.014416	0.21589	69.369	4.6321	43.091	69.473	112.564	0.08601	0.20753	112
113	250.77	236.08	0.014449	0.21279	69.208	4.6994	43.415	69.180	112.595	0.08656	0.20736	113
114	254.08	239.38	0.014483	0.20974	69.046	4.7677	43.739	68.886	112.626	0.08711	0.20718	114
115	257.42	242.72	0.014517	0.20674	68.883	4.8370	44.065	68.590	112.655	0.08766	0.20701	115
116	260.79	246.10	0.014552	0.20378	68.719	4.9072	44.391	68.291	112.682	0.08821	0.20684	116
117	264.20	249.50	0.014587	0.20087	68.554	4.9784	44.718	67.991	112.709	0.08876	0.20666	117

TABLE I "FREON" 22 SATURATION PROPERTIES—TEMPERATURE TABLE

TEMP. °F	PRESSURE PSIA	PRESSURE PSIG	VOLUME cu ft/lb LIQUID v_f	VOLUME cu ft/lb VAPOR v_g	DENSITY lb/cu ft LIQUID $1/v_f$	DENSITY lb/cu ft VAPOR $1/v_g$	ENTHALPY Btu/lb LIQUID h_f	ENTHALPY Btu/lb LATENT h_{fg}	ENTHALPY Btu/lb VAPOR h_g	ENTROPY Btu/(lb)(°R) LIQUID s_f	ENTROPY Btu/(lb)(°R) VAPOR s_g	TEMP. °F
10	47.464	32.768	0.012088	1.1290	82.724	0.88571	13.104	92.338	105.442	0.02932	0.22592	10
11	48.423	33.727	0.012105	1.1077	82.612	0.90275	13.376	92.162	105.538	0.02990	0.22570	11
12	49.396	34.700	0.012121	1.0869	82.501	0.92005	13.648	91.986	105.633	0.03047	0.22548	12
13	50.384	35.688	0.012138	1.0665	82.389	0.93761	13.920	91.808	105.728	0.03104	0.22527	13
14	51.387	36.691	0.012154	1.0466	82.276	0.95544	14.193	91.630	105.823	0.03161	0.22505	14
15	52.405	37.709	0.012171	1.0272	82.164	0.97352	14.466	91.451	105.917	0.03218	0.22484	15
16	53.438	38.742	0.012188	1.0082	82.051	0.99188	14.739	91.272	106.011	0.03275	0.22463	16
17	54.487	39.791	0.012204	0.98961	81.938	1.0105	15.013	91.091	106.105	0.03332	0.22442	17
18	55.551	40.855	0.012221	0.97144	81.825	1.0294	15.288	90.910	106.198	0.03389	0.22421	18
19	56.631	41.935	0.012238	0.95368	81.711	1.0486	15.562	90.728	106.290	0.03446	0.22400	19
20	57.727	43.031	0.012255	0.93631	81.597	1.0680	15.837	90.545	106.383	0.03503	0.22379	20
21	58.839	44.143	0.012273	0.91932	81.483	1.0878	16.113	90.362	106.475	0.03560	0.22358	21
22	59.967	45.271	0.012290	0.90270	81.368	1.1078	16.389	90.178	106.566	0.03617	0.22338	22
23	61.111	46.415	0.012307	0.88645	81.253	1.1281	16.665	89.993	106.657	0.03674	0.22318	23
24	62.272	47.576	0.012325	0.87055	81.138	1.1487	16.942	89.807	106.748	0.03730	0.22297	24
25	63.450	48.754	0.012342	0.85500	81.023	1.1696	17.219	89.620	106.839	0.03787	0.22277	25
26	64.644	49.948	0.012360	0.83978	80.907	1.1908	17.496	89.433	106.928	0.03844	0.22257	26
27	65.855	51.159	0.012378	0.82488	80.791	1.2123	17.774	89.244	107.018	0.03900	0.22237	27
28	67.083	52.387	0.012395	0.81031	80.675	1.2341	18.052	89.055	107.107	0.03958	0.22217	28
29	68.328	53.632	0.012413	0.79604	80.558	1.2562	18.330	88.865	107.196	0.04013	0.22198	29
30	69.591	54.895	0.012431	0.78208	80.441	1.2786	18.609	88.674	107.284	0.04070	0.22178	30
31	70.871	56.175	0.012450	0.76842	80.324	1.3014	18.889	88.483	107.372	0.04126	0.22158	31
32	72.169	57.473	0.012468	0.75503	80.207	1.3244	19.169	88.290	107.459	0.04182	0.22139	32
33	73.485	58.789	0.012486	0.74194	80.089	1.3478	19.449	88.097	107.546	0.04239	0.22119	33
34	74.818	60.122	0.012505	0.72911	79.971	1.3715	19.729	87.903	107.632	0.04295	0.22100	34
35	76.170	61.474	0.012523	0.71655	79.852	1.3956	20.010	87.708	107.719	0.04351	0.22081	35
36	77.540	62.844	0.012542	0.70425	79.733	1.4199	20.292	87.512	107.804	0.04407	0.22062	36
37	78.929	64.233	0.012561	0.69221	79.614	1.4447	20.574	87.316	107.889	0.04464	0.22043	37
38	80.336	65.640	0.012579	0.68041	79.495	1.4697	20.856	87.118	107.974	0.04520	0.22024	38
39	81.761	67.065	0.012598	0.66885	79.375	1.4951	21.138	86.920	108.058	0.04576	0.22005	39
40	83.206	68.510	0.012618	0.65753	79.255	1.5208	21.422	86.720	108.142	0.04632	0.21986	40
41	84.670	69.974	0.012637	0.64643	79.134	1.5469	21.705	86.520	108.225	0.04688	0.21968	41
42	86.153	71.457	0.012656	0.63557	79.013	1.5734	21.989	86.319	108.308	0.04744	0.21949	42
43	87.655	72.959	0.012676	0.62492	78.892	1.6002	22.273	86.117	108.390	0.04800	0.21931	43
44	89.177	74.481	0.012695	0.61448	78.770	1.6274	22.558	85.914	108.472	0.04855	0.21912	44
45	90.719	76.023	0.012715	0.60425	78.648	1.6549	22.843	85.710	108.553	0.04911	0.21894	45
46	92.280	77.584	0.012735	0.59422	78.526	1.6829	23.129	85.506	108.634	0.04967	0.21876	46
47	93.861	79.165	0.012755	0.58440	78.403	1.7112	23.415	85.300	108.715	0.05023	0.21858	47
48	95.463	80.767	0.012775	0.57476	78.280	1.7398	23.701	85.094	108.795	0.05079	0.21839	48
49	97.085	82.389	0.012795	0.56532	78.157	1.7689	23.988	84.886	108.874	0.05134	0.21821	49
50	98.727	84.031	0.012815	0.55606	78.033	1.7984	24.275	84.678	108.953	0.05190	0.21803	50
51	100.39	85.69	0.012836	0.54698	77.909	1.8282	24.563	84.468	109.031	0.05245	0.21785	51
52	102.07	87.38	0.012856	0.53808	77.784	1.8585	24.851	84.258	109.109	0.05301	0.21768	52
53	103.78	89.08	0.012877	0.52934	77.659	1.8891	25.139	84.047	109.186	0.05357	0.21750	53
54	105.50	90.81	0.012898	0.52078	77.534	1.9202	25.429	83.834	109.263	0.05412	0.21732	54
55	107.25	92.56	0.012919	0.51238	77.408	1.9517	25.718	83.621	109.339	0.05468	0.21714	55
56	109.02	94.32	0.012940	0.50414	77.232	1.9836	26.008	83.407	109.415	0.05523	0.21697	56
57	110.81	96.11	0.012961	0.49606	77.155	2.0159	26.298	83.191	109.490	0.05579	0.21679	57
58	112.62	97.93	0.012982	0.48813	77.028	2.0486	26.589	82.975	109.564	0.05634	0.21662	58
59	114.46	99.76	0.013004	0.48035	76.900	2.0818	26.880	82.758	109.638	0.05689	0.21644	59

Name:______

Date:_______

Project 16

Division of Decimal Numbers Applied to the Capacity of Evaporator Coils

Objective: The purpose of this project is to practice the division of decimal numbers as the process applies to the application of evaporator coils used in the HVAC industry.

Procedure: Each student will be assigned sample evaporator coils taken from 07.03a. Referring to the information at 7.03b and based on the model number of the coil and the number of fins per inch on each coil, the student will solve for the missing information below

The student will assume 12,000 BTUs equals one ton of refrigeration.

Evaporator Coil	**TD**	**Capacity in Tons**	**Capacity in BTUs**
U.U1-118	**10**		
UAH1-365		**2.3**	
UAH3-648			**97,200**
UAH1-182	**18**		
UAM2-441	**10**		

Note: TD = the temperature difference between evaporator temperature and fixture temperature.

Evaporator Temperature and Relative Humidity

Proper sizing of the evaporator coil determines the temperature and the humidity in the space to be conditioned.

To know the acceptable evaporator temperature on a system, one must know the required temperature difference between the fixture and the evaporator. In order to know this information, we must know the desired fixture temperature and the average relative humidity for the application. Pages 18 - 20 from the Russell Manual lists some of the common applications with the average fixture temperature and relative humidity.

The refrigerant or evaporator temperature is the temperature corresponding to the suction gage pressure, less line loss (if known). It is not the temperature of the coil or the air leaving the coil.

The wider the split between fixture and evaporator, or the colder the temperature of the refrigerant in relation to the temperature of the fixture, the higher the latent heat removal. An increase in latent heat removal will result in lower relative humidity within the fixture.

The lower the split between fixture and evaporator, the lower the latent heat removal and the higher the relative humidity of the fixture.

The relationship between evaporator capacity, T.D. and area of the evaporator is:

BTU/hr = U X T.D. X Area

Where: U is the heat transfer coefficient of the coil material
T.D. is the temperature difference between fixture and evaporator temperature.
Area is the surface area of the coil exposed to circulating air in square feet.

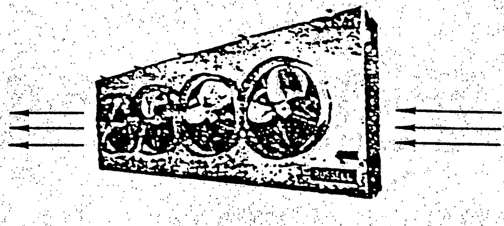
Following, is the average T. D. between evaporator and fixture and the resulting relative humidity.

T.D.	RH%	T.D.	RH%
10 - 15	95 - 90%	25 - 30	75 - 65%
15 - 18	90 - 85%	30 - 35	65 - 55%
18 - 22	85 - 80%	35 - 40	55 - 50%
22 - 25	80 - 75%	40 - 45	50 - 45%

RUSS PAK COMPLETE REFRIGERATION SYSTEMS WITH LIST PRICES MAY 1983 RP

UT ULTRA TEMP

ULTRA HIGH POWERED UNIT COOLERS



Russell's new Ultra Temp unit cooler is exceptionally versatile, covering all temperature applications in a compact, slim profile design. The Ultra Temp is ideally suited for large walk-ins, storage and freezers. Air throw is upto 100 feet with optional metal air straighteners.

Low Temperature Models
With Electric Defrost

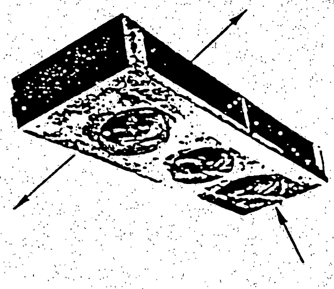
Model	BTU/HR 10° TD	BTU/HR 12° TD	Fan Dia.	Motor H.P.	W	H	D	WL
4 Fins per Inch -30° Evap Temperature—Electric or Hot-Gas Defrost								
U•U1-118	11,800	14,200	20	3/4	46½	25½	21¼	190
U•U2-236	23,600	28,300	20	3/4	76½	25½	21¼	370
U•U2-355	35,500	42,600	20	3/4	76½	31½	21¼	440
U•U3-474	47,400	56,900	20	3/4	106½	31½	21¼	570
U•U4-711	71,100	85,300	20	3/4	136½	31½	21¼	665
U•U4-851	85,100	102,100	24	3/4	136½	49½	23¾	875
U•U4-1080	108,000	129,600	24	3/4	136½	49½	23¾	900
6 Fins per Inch -10° Evap Temperature—Electric or Hot-Gas Defrost								
U•L1-152	15,200	18,200	20	3/4	46½	25½	21¼	200
U•L1-193	19,300	23,200	20	3/4	46½	25½	21¼	220
U•L2-304	30,400	36,500	20	3/4	76½	25½	21¼	400
U•L2-361	36,100	43,300	20	3/4	76½	31½	21¼	425
U•L2-408	40,800	49,000	20	3/4	76½	31½	21¼	446
U•L3-540	54,000	64,800	20	3/4	106½	31½	21¼	585
U•L3-613	61,300	73,600	20	3/4	106½	31½	21¼	620
U•L4-722	72,200	86,600	20	3/4	136½	31½	21¼	675
U•L4-817	81,700	98,000	20	3/4	136½	31½	21¼	726
U•L4-1100	110,000	132,000	24	3/4	136½	49½	23¾	885
U•L4-1380	138,000	165,600	24	3/4	136½	49½	23¾	910

Air Defrost Models

Model	BTU/HR 10° TD	BTU/HR 15° TD	Fan Dia.	Motor H.P.	W	H	D	WL
6 Fins per Inch +25° Evap Temperature—Air Defrost								
UAM1-164	16,400	24,600	20	1/3	46½	25½	21¼	200
UAM1-209	20,900	31,350	20	1/3	46½	25½	21¼	220
UAM2-329	32,900	49,350	20	1/3	76½	31½	21¼	400
UAM2-390	39,000	58,500	20	1/3	76½	31½	21¼	425
UAM2-441	44,100	66,150	20	1/3	76½	31½	21¼	446
UAM3-583	58,300	87,450	20	1/3	106½	31½	21¼	585
UAM3-662	66,200	99,300	20	1/3	106½	31½	21¼	620
UAM4-780	78,000	117,000	20	1/3	136½	31½	21¼	675
UAM4-882	88,200	132,300	20	1/3	136½	31½	21¼	726
UAM4-1320	132,000	198,000	24	3/4	136½	49½	23¾	885
UAM4-1656	165,600	248,400	24	3/4	136½	49½	23¾	910
8 Fins per Inch +25° Evap Temperature—Air Defrost								
UAH1-182	18,200	27,300	20	1/3	46½	25½	21¼	210
UAH1-232	23,200	34,800	20	1/3	46½	25½	21¼	230
UAH2-365	36,500	54,750	20	1/3	76½	31½	21¼	410
UAH2-433	43,300	64,950	20	1/3	76½	31½	21¼	435
UAH2-490	49,000	73,500	20	1/3	76½	31½	21¼	458
UAH3-648	64,800	97,200	20	1/3	106½	31½	21¼	600
UAH3-736	73,600	110,400	20	1/3	106½	31½	21¼	635
UAH4-866	86,600	129,900	20	1/3	136½	31½	21¼	690
UAH4-980	98,000	147,000	20	1/3	136½	31½	21¼	746
UAH4-1452	145,200	217,800	24	3/4	136½	49½	23¾	905
UAH4-1821	182,100	273,150	24	3/4	136½	49½	23¾	930

FL FLOW-TEMP

LOW VELOCITY UNIT COOLERS



Model	BTU/HR. 10° TD	BTU/HR. 12° TD	Fans No. — Diam.	Fan Motor H.P.	Dimensions D	W	H	WL
FL26-67	6,700	8,040	2-10	9W	27½	58½	8½	100
FL36-100	10,000	12,000	3-10	9W	27½	82½	9	160
FL36-135	13,500	16,200	3-10	16W	27½	82½	12	207
FL46-180	18,000	21,600	4-10	16W	27½	106½	12	291
FL46-265	26,500	31,800	4-10	16W	27½	106½	15	320

The Russell Flow Temp Unit Cooler was first introduced to the refrigeration industry in 1964 to answer the many requests for reduced velocity applications. It is especially designed for high humidity applications where meat shrinkage in cutting and storage rooms is a factor. It has an extremely comfortable sound level. Thousands have been in use in meat cutting, holding and packaging rooms, fruit and vegetable storage rooms and florist boxes. Flow-Temps come with a white baked polyester coating on the housing.

All of the above Unit Coolers are UL listed and are made for standard air defrost as well as electric defrost.

TESTING:

Each Russ Pak system is assembled under strict quality control. The condensing unit is pressurized for leak detection, then fully evacuated to 200 microns pressure. The electrical circuit is given a full dielectric test prior to the unit being given a complete run test. The unit is prepared for shipment with a holding charge of dry nitrogen.

Objective: After satisfactorily completing this lesson, each student should be able to:
1. Understand the concept of surface and volume measure.
2. Solve practical problems relating to the volume of cubes, cylinders, and irregular forms.
3. Apply units of volume to solve problems related to liquid measure.

Information: Basic vocational-technical mathematics by Olivo & Olivo, Units 20&21.

Essential Concepts:
1. Surface measure refers to the measurement of an object that has length and height.
2. Volume measure refers to the measurement of three linear dimensions: length, height, and depth.

Structure:
The instructor will discuss the essential concepts of the lesson. In order to reinforce the essential concepts, the instructor will review the rule for applying surface measure to cubes and circles, the rule for finding the area of a cube, and the rule for finding the volume of a cylinder. When no further questions about the essential concepts or rules are observed, the students will complete three in-class projects.

1. Surface Measure and Conversion to Equivalent Units.
   Each student will measure the total area of window exposure for an assigned class room and express the units in square feet. The lab can be found at 8.01.

2. Volume Measure
   The student will be assigned a reciprocating compressor. After removing the cylinder head and valve plates, the student will determine the total volume of the compressor cylinders and express the answer in cubic inches and cubic feet. The lab project can be found at 8.02.

3. Volume measure
   The student will be assigned various walk-in freezers and refrigerators in order to determine the interior volume expressed in cubic feet. The lab project can be found at 8.03.

Evaluation:
There are six points possible for this activity. Each student completing all three projects will receive full credit for this activity. Students who do not come prepared, do not participate, or fail to complete a project will loose one point for each criteria they fail to meet.

08.01
AIRC 10
Project 17

Name:______
Date:_______

Surface Measure and Conversion to Equivalent Units

Objective: The purpose of this project is to practice the measurement of surface area.

Procedure: Each student will measure the surface area of the following structures and record the answers in square feet:

1. Floor space of AIRC lab 21-8. ________________
2. Floor space of AIRC lab 21-1&3 ________________
3. Window surface area of AIRC lab 21 - 1&3 ________________
4. Fenced yard space behind AIRC lab 21-1&3 ________________
5. Window surface area of AIRC lab 21-8 ________________
6. What is the total floor space allocated to the AIRC Department? ________________

08.02
AIRC 10
Project 18

Name:______
Date:______

Volume Measure of a Compressor Cylinder

Objective: The purpose of this project is to practice the measurement of volume for applications related the HVAC industry.

Procedure: The student will be assigned three reciprocating compressors. After removing the cylinder head and valve plates from the compressor, the student will determine the total volume of the compressor cylinders and express the answer in cubic feet and cubic inches. The student will refer the reference material at 8.02a-c for compressor disassembles.

Compressor #1

Model#__________ Piston Displacement:___________

Compressor #2

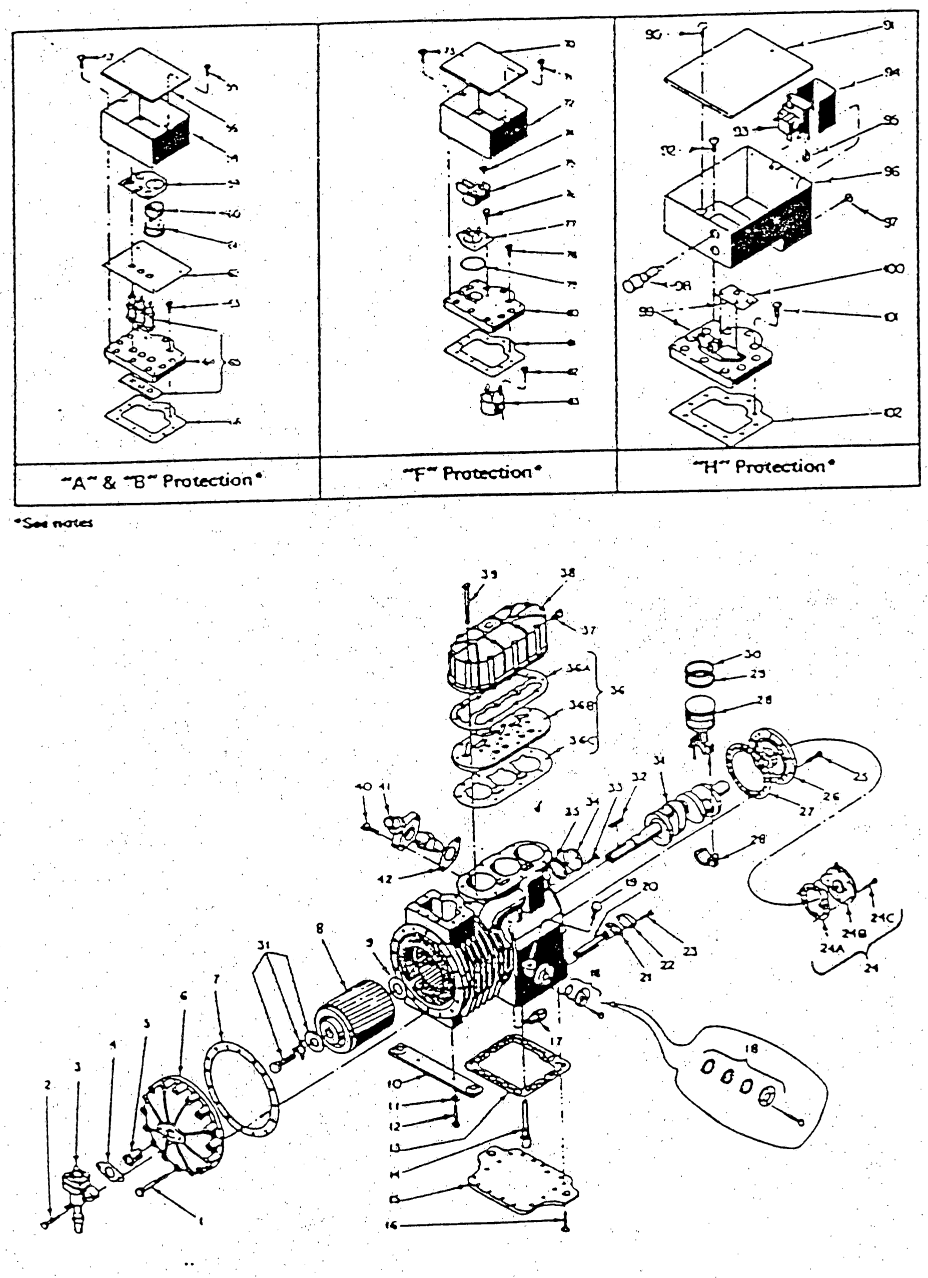
Model#__________ Piston Displacement:___________

Compressor #3

Model#__________ Piston Displacement:___________

COPELAND COPELAMETIC
9R38—9R8—9RA1—9RJ1—9TK1

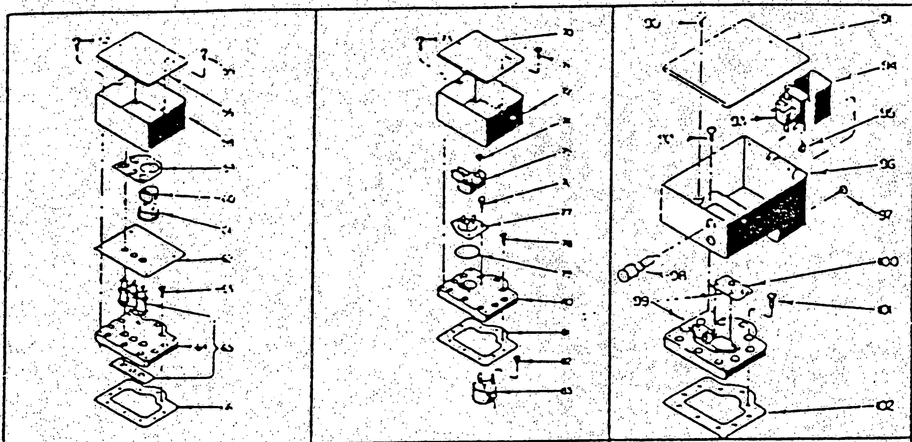
COMPRESSOR PARTS



EXPLODED VIEW

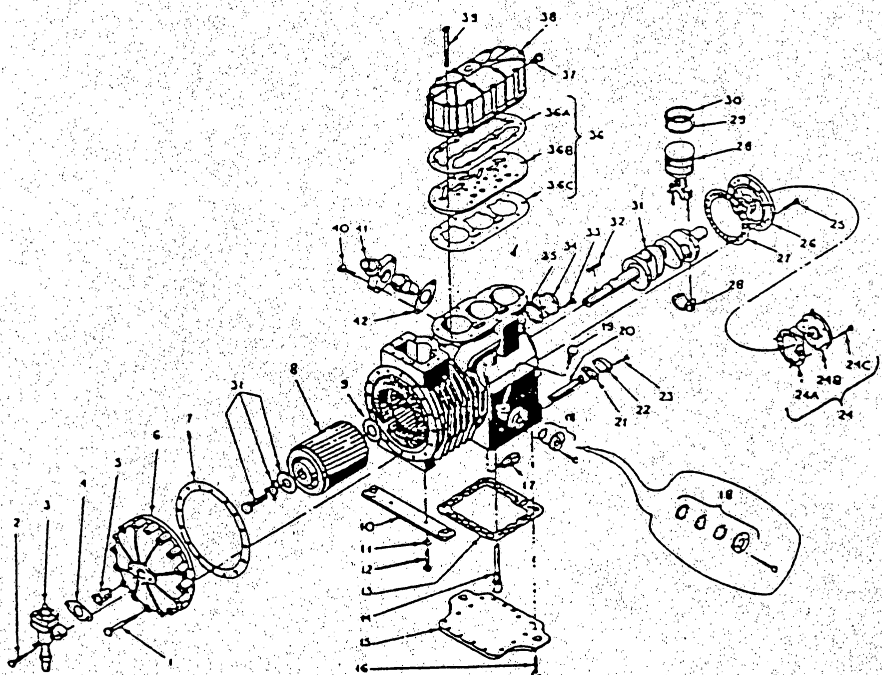
COPELAND COPELAMETIC
9R38—9R8—9RA1—9RJ1—9TK1

COMPRESSOR PARTS



"A" & "B" Protection*	"F" Protection*	"H" Protection*

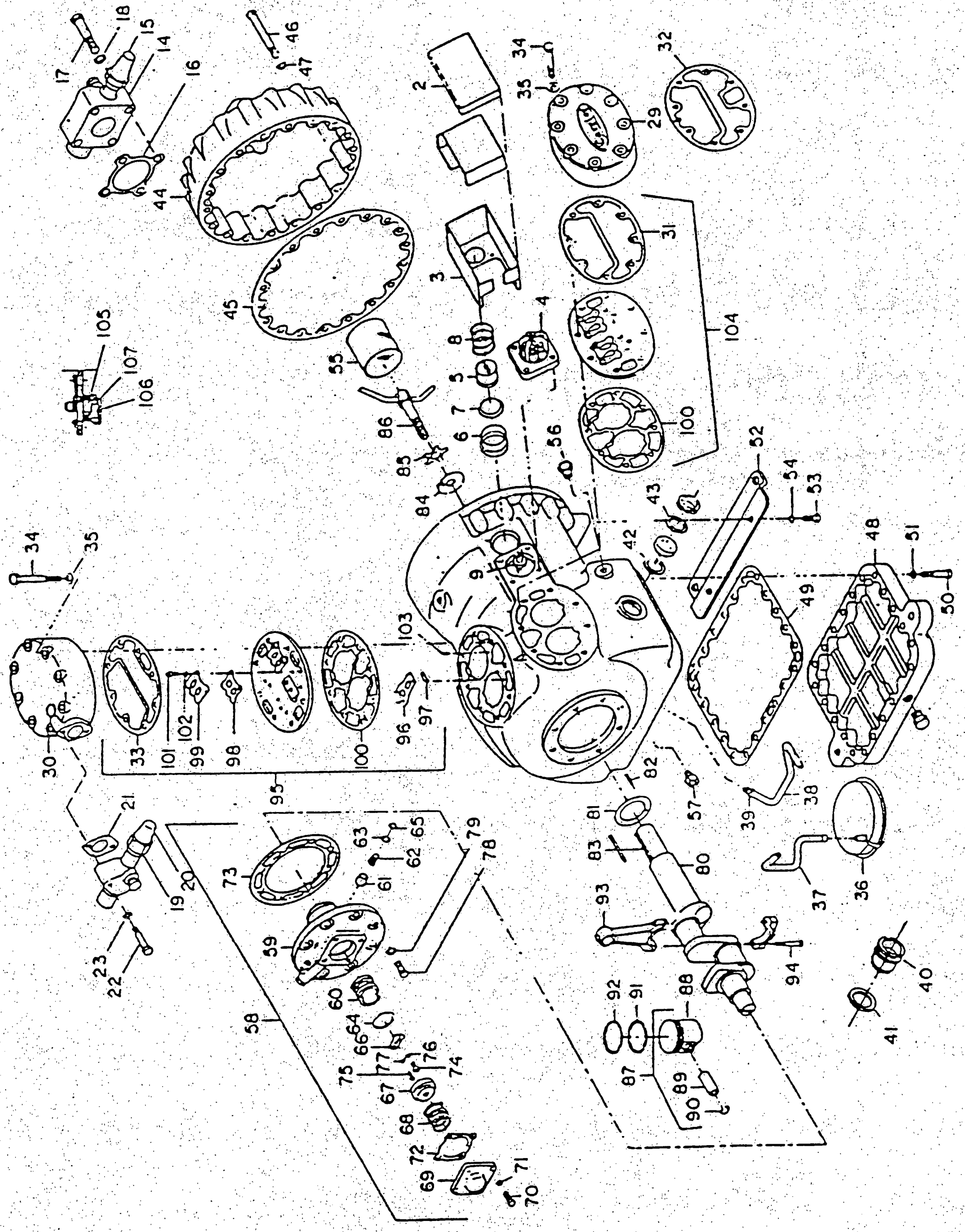
*See notes



EXPLODED VIEW

CARRIER 6D, O6D—6D72-75

COMPRESSOR PARTS



See Following Pages for Parts List

08.03
AIRC 10
Project 19

Name:______
Date:_______

Volume Measure of a Liquid Receiver

Objective: The purpose of this project is to practice the measurement of volume for applications related the HVAC industry and apply the information learned in a previous lab to convert volume to liquid measure.

Procedure: Each student will be assigned four refrigeration systems using a liquid receiver to store refrigerant. The student will determine the volume of the liquid receiver and then refer to lab 7.02 to determine the amount of refrigerant charge required by the refrigeration system. The receiver should be able to handle 80% of the entire refrigerant charge.

Refrigeration System #	Receiver Volume	Refrigerant Weight in lbs.
16		
19		
22		
35		

Objective: After satisfactorily completing this lesson, each student should be able to:
1. Determine base, rate, or percentage values in practical HVAC problems.
2. Compute the average of several quantities

Information: Basic vocational-technical mathematics by Olivo & Olivo, Units 24&25.

Essential Concepts:
1. Percent is a method of writing decimals as whole numbers.
2. The average of two or more quantities is found by simple addition and division.

Structure:
The instructor will discuss the essential concepts of the lesson. In order to reinforce the essential concepts, the instructor will review the rule for finding percentage when base and rate is given, the rule for finding base or rate when the percentage is given, and the rule for averaging quantities based on the assigned reading. When no further questions about the essential concepts or rules are observed, the students will complete three in-class projects.

1. Determining Percentage
   Each student will be assigned one air conditioning system and one refrigeration system. Based on the name plate or the size of the receiver the student will determine the volume of the refrigerant charge of each system. The student will then determine the allowable annual loss based on the 15%-30% EPA rule. The lab project is located at 9.02.

2. Determining Percentage
   Each lab group will determine the actual capacity of a refrigeration system based upon the system operational performance. The lab group will operate the system and then record its performance characteristics. The characteristics recorded will then be matched with capacity multipliers that will determine the systems actual capacity.

3. Determining Average
   Each lab group will be assigned a refrigeration system operating on three phase electricity. The lab group will solve for voltage imbalance by averaging the current and voltage. The lab project is located at 9.03.

Evaluation:
There are six points possible for this activity. Students who do not come prepared, or fail to complete a project will loose credit for each project they fail to complete.

09.01
AIRC 10
Project 20

Name:______
Date:_______

Determining Percentage of Allowable Refrigerant Loss

Objective: The purpose of this project is to find the allowable annual loss of refrigerant charge for an air conditioning or refrigeration system based upon Section 608 of the Clean Air Act.

Information: Effective July 13, 1993 any annualized leak rate of 35% or more in commercial refrigeration or industrial process equipment must be repaired. For appliances other than industrial process equipment and commercial refrigeration, an annual leak rate of 15% must be repaired.

Procedure: Each student will be assigned a series of air conditioning and refrigeration systems. Based on the name plate refrigerant charge, or the size of the receiver found in lab 8.03, the student will determine the volume of the refrigerant charge in each system. The student will then determine the allowable annual loss based on the 15%-35% EPA rule.

Refrigeration System #	Refrigerant Charge in lbs.	Allowable Loss in lbs.
16		
19		
22		
35		

09.03
AIRC 10
Project 22

Name:______
Date:_______

Solve for Voltage and Current Imbalance by Averaging

Objective: The purpose of this project is to use the process of averaging to determine if a voltage or current imbalance exists in a three phase electrical circuit.

Information: Voltage imbalance is very important when working with three phase motors. A small unbalance in a phase-to phase voltage can result in a much greater current unbalance. With unbalanced current the heat generated in the motor will increase and may result in motor failure. For this reason, never run a motor where a greater than 2% voltage phase unbalance exists.

Procedure: Each student will be assigned an air conditioning or refrigeration unit operating on three phase electricity. The student will open the disconnect switch supplying the refrigeration unit and check the incoming phase-to-phase voltage between conductors A-B, A-C, B-C. Percentage of voltage unbalance is found by dividing the maximum voltage deviation from the average by the average voltage, or:

% Voltage Unbalance = Max. E deviation from Avg. E / Avg. E

Determine Max. Deviation

	Voltage	Deviation from Avg.
(A-B)	______	_______
(A-C)	______	_______
(B-C)	______	_______

Objective: After successfully completing this lesson, each student should be able to:
1. Relate signed numbers to appropriate values on line-graduated measuring instruments.
2. Solve practical problems of addition and of numbers with positive or negative values.
3. Solve practical problems of addition and subtraction of numbers with positive or negative values.

Information: Basic vocational-technical mathematics by Olivo & Olivo, Unit 47&48.

Essential Concepts:
1. Positive and negative numbers reflect a numerical direction from a fixed reference point, usually zero.
2. Any value less than zero is referred to as a negative quantity. Any value more than zero is a positive quality

Structure:
The instructor will discuss the essential concepts of the lesson. To reinforce the essential concepts, the instructor will review the rule for adding signed numbers with unlike signs, the rule for subtracting signed numbers, the rule for multiplying positive and negative signed numbers, and the rule dividing signed numbers with unlike signs based on the assigned reading. When no further questions about the essential concepts or rules are observed, the students will complete two in-class projects.

1. Each student will be complete a written assignment that reinforces the concepts of addition and subtraction of signed numbers, and the multiplication and division of signed numbers. This project is located at 11.01.

2. Subtraction of Negative and Positive Quantities.
   Each student will determine the pressure drop through the vapor line of a refrigeration unit and compare the results to field standards. Pressure drop is determined by recording the actual evaporator temperature and converting to pressure, and then subtracting the actual suction pressure at the compressor. This project is located at 11.02

Evaluation:
There are six points possible for these activities. Each student completing both projects will receive full credit. Students who do not come prepared, do not participate, or fail to complete a project will loose two points for each activity they fail to complete.

11.01
AIRC 10
Project 24

Name:______
Date:_______

Subtraction of Negative and Positive Quantities

Objective: The purpose of this project is to practice the subtraction of negative and positive quantities as the process applies to pressure drop in the refrigerant lines of an air conditioning or refrigeration system.

Information: It is common practice in the refrigeration industry to express the recommended design pressure drops in refrigerant lines as an equivalent temperature change. The equivalent temperature change is defined as the corresponding change in saturation temperature that would occur for the pressure drop specified. The equivalent temperature change is a useful way of expressing pressure drop because the ratings of compressors are based on saturated suction and discharge temperatures.

Procedure: Each lab group will be assigned a low temperature refrigeration system. The group will operate the assigned system for of minimum of 15 minutes to allow for stabilization. Once the unit has stabilized, The lab group will measure and record the actual evaporator temperature by applying an infrared or electronic thermometer to the evaporator coil. The lab group will apply refrigeration gages to the suction line service valve in order to measure and record the suction saturation temperature. From the saturation property tables located at 7.02a-b, the pressure drop can be found by

P_{sat} at evap.
\- $\underline{P_{sat}\text{ at comp.}}$
pressure drop in psig

Refrigeration System #	P_{sat} at the evaporator	P_{sat} at the compressor	Pressure drop in psig
16			
22			

Objective: After satisfactorily completing this lesson, each student should be able to:
1. Convert from one set of units to another and properly round off all numbers.
2. Solve for basic units of measurement used in the HVAC industry including: density, specific volume, and specific gravity.

Information: Basic vocational-technical mathematics by Olivo & Olivo, Unit 39. Refrigeration principles and systems by Edward G. Pita Chapter 1 and Appendix 2.

Essential Concept:
1. There are different units of measurement for the same physical characteristics. These units have a fixed relationship called equivalents or conversion factors

Structure:
In order to reinforce the essential concepts, the instructor will demonstrate the process of converting unit equivalents taken from 12.01, solve for the basic units of measurement, and define the relationship between the three units of pressure. When no further questions about the essential concepts or processes are observed, the students will complete three in-class projects.

1. Units and Conversion
   Each student will complete the written assignment at that reinforces the process of changing quantities from original units to new units. The assignment can be found at 12.02.

2. Solving for Mass.
   Each student will be required to complete a lab project that solves for the mass of water and pressure exerted in cooling towers located in the AIRC mechanical lab. The lab can be located at 12.03

3. Solving for Absolute, Gage and Vacuum Pressures.
   Each lab group will evacuate a refrigeration system with a vacuum pump. The group members will determine the pressure reduction using a mercury manometer, or a micrometer. The readings will be expressed in absolute pressure for the following units: Hg vac, psi, microns. The lab is located at 12.04.

Evaluation:
There are six points possible for these activities.. Students who do not come prepared, do not participate, or fail to complete a project will loose credit for each activity they fail to complete.

12.01
AIRC 10
Project 25

Name:______
Date:_______

Units and Conversion

Objective: The purpose of this project is to apply conversion factors used in the HVAC industry in order to determine mechanical equivalencies.

Procedure: Each student will refer to the conversion factors at 12.01a to solve for the equivalencies below. Include all arithmetic on a separate sheet of paper and reference the solutions to the specific problem.

1. 85 psig = _____Ft. w.
2. 14.5 ft3/sec = ____gal/min.
3. 83,200 Btu/hr = ____tons.
4. 7.62 in Hg. = ____psig
5. 12.6 hp = ____Btu/min
6. 24,000 Btu/hr = ___kW
7. 5 hp = ____Kw
8. 10,000Btu/hr = ____hp
9. 4 gal H20 = ____lbs
10. 4 gal H20 = ____ft3
11. 150,000Btu/hr = ____hp
12. 12 psig = ____ft. w
13. 4 psig = ____in. Hg
14. 12,300 Btu/hr = ____kW
15. 7.5 hp = ____kW
16. 256 kW = ____hp
17. 100 F = ____C
18. 212 F = ____C
19. 33 C = ____F
20. 65 C = ____F
21. 750 gal = ____lbs H20
22. 35 lbs = ____gal H20
23. 9.5 tons = _____Btu/hr
24. 5 tons = ____Btu/min
25. 12 psig = ____ft.w
26. 3 tons = ____kW
27. 3 tons = ____Hp
28. 160 kW = ____hp.
29. 4.5 hp. = ____kW
30. 22psig = ____in. Hg
31. 22 gal H20 = ____ft3
32. 2 hp = ____Btu/hr

12.01a

Appendix 2

UNIT EQUIVALENTS (CONVERSION FACTORS)

To change from one set ofunits to another, multiply known quantity and unit by the ratio of unit equivalents that results in the desired units.

LENGTH
U.S.: 12 in. = 1 ft = 0.333 yd
metric: 1 m = 100 cm = 1000 mm = 10^{-3} km = 10^{6} microns
U.S.–metric: 1 ft = 0.30 m
SI unit is the m

AREA
U.S.: 144 in.^{2} = 1 ft^2
U.S.–metric: 1 ft^2 = 0.093 m^2
SI unit is the m^2

VOLUME
U.S.: 1728 in.^{3} = 1 ft^3 = 7.48 gal.
U.S.–metric: 1 ft^3 = 0.0283 m^3
SI unit is the m^3

MASS
U.S.: 1 lb = 16 oz
metric: 1 kg = 1000 g
U.S.–metric: 2.2 lb = 1 kg
SI unit is the kg

FORCE
U.S.–metric: 1 lb = 4.45 N
SI unit is the N

VELOCITY
U.S.: 1 ft/sec = 0.68 mi/hr
SI unit is the m/sec

DENSITY
U.S.–metric: 1 lb/ft^3 = 16.0 kg/m^3
SI unit is the kg/m^3

PRESSURE
U.S.: 1 psi = 2.3 ft w. = 2.04 in. Hg
metric: 1 atm = 101,300 N/m^3
1 mm Hg = 133.3 Pa
U.S.–metric: 14.7 psi = 1 atm
SI unit is the N/m^2 (Pa)

TEMPERATURE
U.S.: F = R − 460
metric: °C = °K − 273
U.S.–metric: °F = (9/5)° C + 32; °C = 5/9 (°F − 32)
SI unit is the °K

ENERGY
U.S.: 1 Btu = 778 ft-lb
metric: 1 J = 1 W-sec = 0.239 cal
U.S.–metric: 1 Btu = 1055 J = 252 cal
SI unit is the J

POWER (RATE OF ENERGY)
2545 Btu/hr = 1 hp = 0.746 kW
= 33,000 ft-lb/min
3410 Btu/hr = 1 kW
1 ton of refrigeration = 12,000 Btu/hr
= 4.72 HP = 3.52 kW
SI unit is the W

SPECIFIC HEAT
U.S.–metric: 1 Btu/lb-F = 1 cal/gm-°C = 4.2 kJ/kg-°C

HEAT TRANSFER COEFFICIENT U
U.S.–metric: 1 Btu/hr-ft^2-°F = 5.68 W/m^2-°C

VOLUME FLOW RATE
U.S.–metric: 1 CFM = 1.70 m^3/hr

USEFUL EQUIVALENTS FOR WATER ONLY (AT 60°F)
Density: 8.33 lb = 1 gal
62.4 lb = 1 ft^3
Flow rate: 1 GPM = 500 lb/hr

12.02
AIRC 10
Project 26

Name:______
Date:_______

Solving for Mass in Cooling Towers

Objective: The purpose of this project is to allow the student to apply units of conversion to practical applications of determining the mass of equipment found in the HVAC industry.

Procedure: Each student is required to determine the mass and the density of water in the basins of two cooling towers located in the mechanical refrigeration lab. The mass of water in the basins are found from the equations below. The approximate density of water can be found at 12.02a.

$$d = m \,/\, \text{volume}$$

$$v = \text{volume} \,/\, m$$

Where d = density, v = specific volume , and m = mass

Cooling Tower #	Water Volume	Water Mass	Specific Volume
40			
43			

Appendix 3

WATER: PROPERTIES OF LIQUID AND SATURATED VAPOR (U.S. UNITS)

		Specific Volume, ft^3/lb		Specific Enthalpy, Btu/lb			
Temperature, °F	Pressure, psia	Liquid, v_f	Vapor, v_g	Liquid, h_f	Latent, h_{fg}	Vapor, h_g	Temperature °F
32	0.089	0.016	3305	0.02	1075.5	1075.5	32
35	0.099	0.016	2948	3.00	1073.8	1076.8	35
40	0.122	0.016	2446	8.03	1071.0	1079.0	40
45	0.147	0.016	2037.8	13.04	1068.1	1081.2	45
50	0.178	0.016	1704.8	18.05	1065.3	1083.4	50
60	0.256	0.016	1207.6	28.06	1059.7	1087.7	60
70	0.363	0.016	868.4	38.05	1054.0	1092.1	70
80	0.507	0.016	633.3	48.04	1048.4	1096.4	80
90	0.698	0.016	468.1	58.02	1042.7	1100.8	90
100	0.949	0.016	350.4	68.00	1037.1	1105.1	100
110	1.27	0.016	265.4	77.98	1031.4	1109.3	110
120	1.69	0.016	203.26	87.97	1025.6	1113.6	120
130	2.22	0.016	157.33	97.96	1019.8	1117.8	130
140	2.89	0.016	123.00	107.9	1014.0	1122.0	140
150	3.72	0.016	97.07	117.9	1008.2	1126.1	150
160	4.74	0.016	77.29	127.9	1002.2	1130.2	160
170	5.99	0.016	62.06	137.9	996.2	1134.2	170
180	7.51	0.016	50.22	148.0	990.2	1138.2	180
190	9.34	0.017	40.96	158.0	984.1	1142.1	190
200	11.52	0.017	33.64	168.0	977.9	1146.0	200
210	14.12	0.017	27.82	178.1	971.6	1149.7	210
212	14.7	0.017	26.80	180.1	970.3	1150.5	212
220	17.18	0.017	23.15	188.2	965.2	1153.4	220
230	20.8	0.017	19.38	198.3	958.7	1157.1	230
240	24.9	0.017	16.32	208.4	952.1	1160.6	240
250	29.8	0.017	13.81	218.5	945.4	1164.0	250
260	35.4	0.017	11.76	228.7	938.6	1167.4	260
270	41.8	0.017	10.06	238.9	931.7	1170.6	270
280	49.2	0.017	8.64	249.1	924.6	1173.8	280
290	57.5	0.017	7.46	259.4	917.4	1176.8	290
300	67.0	0.017	6.46	269.7	910.0	1179.7	300
310	77.6	0.017	5.62	280.0	902.5	1182.5	310
320	89.6	0.018	4.91	290.4	894.8	1185.2	320
340	118.0	0.018	3.78	311.3	878.8	1190.1	340
360	153.0	0.018	2.95	332.3	862.1	1194.4	360
380	195.7	0.018	2.33	353.6	844.5	1198.0	380
400	247.2	0.019	1.863	375.1	825.9	1201.0	400
420	308.7	0.019	1.499	396.9	806.2	1203.1	420
440	381.5	0.019	1.216	419.0	785.4	1204.4	440
460	466.9	0.019	0.994	441.5	763.2	1204.8	460
480	566.2	0.020	0.817	464.5	739.6	1204.1	480

12.03
AIRC 10
Project 27

Name:______
Date:_______

Solving for Absolute, Gage and Vacuum Pressures

Objective: The purpose of this project is to allow the student to apply units of conversion to the practical application of converting from gage pressures to absolute pressures.

Procedure: Each lab group will evacuate an assigned refrigeration or air conditioning system with a vacuum pump. During the process, the lab group will determine how much the pressure has been reduced using a mercury manometer or an electronic micrometer. These values will be converted to absolute pressure.

Evacuate a refrigeration system and record the vacuum at timed intervals.

Time	in Hg.	atm	mm Hg.	psig	psia
0 min					
3 min					
5 min					
10 min					
15 min					
20 min					

Where: Time=time period of vacuum pump operation, in Hg=inches of mecury vacuum,atm=atmospheric pressure, mm Hg.=millimeters of mercury vacuum, psig=pounds per square inch gage pressure, psia=pounds per square inch absolute pressure

Objective: After satisfactorily completing this lesson, each student should be able to:
1. Interpret parts of an equation and interpret the functions equations serve in mathematics
2. Balance and check equations
3. Remove common factors to simplify or reduce an expression to its lowest terms.
4. Transpose terms and solve equations and practical problems.

Information: Basic vocational-technical mathematics by Olivo & Olivo, Unit 54.

Essential Concepts:
1. An equation is a mechanical or scientific statement expressed in mathematical terms.
2. When both members of an equation are equal it is said to be balanced. To maintain balance, the equal members must be increased or decreased, multiplied or divided by equal amounts.

Structure
To reinforce the essential concepts, the instructor will demonstrate the process of collecting terms, the process of removing factors and the process of transposing terms to solve an equation. When no further questions about the essential concepts or processes are observed, the students will complete three projects

1. Solve equations by addition and subtraction
Each student will complete a written assignment that requires solving for micro farad rating of capacitors hooked in series or in parallel. This assignment is located at 13.01.

2. Solve Equations by Multiplication and Division
Each lab group will be assigned an air handler with resistance strip heaters. Based on the sensible heat formula, the group will determine the capacity in BTU/hr of the air handler with resistance heaters operating. This project is located at 13.02.

3. Developing Equations
Each student will complete a written assignment that requires the student to develop a series of equations that illustrate a mechanical or electrical process common to the HVAC industry from assignment 54 of the text book.

Evaluation:
There are six points possible for these activities.. Students who do not come prepared, do not participate, or fail to complete a project will loose credit for each activity they fail to complete.

13.01
AIRC 10
Project 28

Name:______
Date:_______

Solving Equations by Addition and Subtraction

Objective: The purpose of this project is to apply the rules for solving equations by addition or subtraction to practical problems in the HVAC industry.

Procedure: Solve for the following HVAC problems. Include all arithmetic and equations developed on a separate sheet of paper and reference the solutions to the specific problem.

1. Illustrate four capacitors applied in parallel. Their microfarad (*uf*) ratings are 7.5 mfd, 7.5 mfd 15 mfd, and 5 mfd. Determine the total micro farad rating of all four capacitors.

2. Illustrate four capacitors applied in parallel. Their microfarad (*uf*) ratings are 2 mfd, 3 mfd, 12 mfd, and 20 mfd. Determine the total microfarad rating of all four capacitors.

3. Based on the capacitors available in problems 1 and 2, solve for the following problems:

	uf required	*uf* available	*uf* needed
1	20 *uf*	5 *uf*	
2	15 *uf*	7.5 *uf*	
3	12 *uf*	15 *uf*	
4	15 *uf*	0 *uf*	
5	12.5 *uf*	3 *uf*	
6	40 *uf*	10 *uf*	

13.02
AIRC 10

Project 29

Name:______
Date:_______

Solving Equations by Multiplication and Division

Objective: The purpose of this project is to apply the rules for solving equations by multiplication and division to practical problems in the HVAC industry.

Procedure: Each lab group will determine the capacity and the volume of air flow through an air handler that uses resistance heat as the heat source. The sensible heat formula is used to solve for the answer.

$$\text{Btu/hr} = 1.08 \times T \times \text{CFM}$$

Where: T = temperature difference between supply and return air duct, CFM = cubic feet per minute of air volume through the air handler

1. Operate the air handler with the resistance heat energized.
2. Measure the current draw and voltage applied to the strip heaters. Do not include the current draw to the blower motor.
3. From the voltage and amperage draw, determine the wattage consumed by the strip heaters
4. Using conversion factors found in project 12.01, convert wattage to Btu value.
5. Measure the temperature difference between the supply and return air at the air handler.
6. Solve for capacity and air volume based on the sensible heat formula.
7. Show all work on a separate sheet of paper and reference it to this specific project.

Objective: After satisfactorily completing this lesson, each student should be able to:

1. Apply algebraic equations to solve for latent and sensible heat processes in the refrigeration cycle.
2. Simplify equations used in the HVAC industry by applying the axioms of multiplication, and division.
3. Solve basic algebraic equations used in the HVAC industry using the four basic processes of addition, subtraction, multiplication, and division.

Information: Basic vocational-technical mathematics by Olivo & Olivo, Unit 56. Refrigeration principles and systems by Edward G. Pita Chapter 2..

Essential Concept:

1. Refrigeration neither creates or destroys energy. It only transfers energy. This law of thermal dynamics is explained algebraically and demonstrated throughout the refrigeration cycle.

Structure:
To reinforce the essential concepts, the instructor will illustrate the basic formulas for latent and sensible heat changes and simplify the equations based on the axioms of multiplication and division. When no further questions about the essential or processes are observed, the students will be assigned three projects

1. Specific Heat : The Sensible Heat Formula
   Each lab group will be assigned an operating air conditioning system or water chiller. The group will determine the mass flow rate of the cooling medium and then apply the sensible heat formula to solve for sensible cooling capacity. The project is located at 14.01

2. Latent Heat: The Latent Heat Formula
   Upon completion of project #1, the lab group will apply the mass flow rate of the system assigned in project #1 to the latent heat formula in order to solve for total cooling capacity. This project is located at 14.02.

3. Each student will submit a report comparing the difference between sensible heat changes and latent heat changes. The comparison should be based upon the formulas provided earlier.

14.01
AIRC 10
Project 31

Name:______
Date:_______

Determine Specific Heat Changes Using the Sensible Heat Formula

Objective: The purpose of this project is to practice the application of the sensible heat formula to determine the mass flow rate of liquids used for primary and secondary heat transfer in HVAC equipment.

Procedure: Each lab group will be assigned an air conditioning system or water chiller. The group will determine the mass flow rate of the cooling medium and then apply the sensible heat formula to solve for sensible cooling capacity.

1. Determine the volume of water moving throughout the water chiller based on the pressure drop charts located at 14.01a.

2. From 12.01a, determine the mass flow rate of water through the chiller (*m*).

3. Solve for the system capacity using the sensible heat formula.

$$Q = m \text{ x } c \text{ x } TC$$

Where Q = net rate of heat added or removed, *m* = mass flow rate of a substance in lb/hr, TC = the temperature change of the medium cooled or heated, c = the specific heat of the substance heated or cooled. The specific heat of water is 1.

Performance Data — English

LCWT (F)	UNIT 30GB	CONDENSER ENTERING AIR TEMPERATURE (F) — 80: Cap. (Tons)	80: SDT (F)	80: kW	80: Cooler Flow Data Gpm	80: Cooler Flow Data PD	85: Cap. (Tons)	85: SDT (F)	85: kW	85: Cooler Flow Data Gpm	85: Cooler Flow Data PD	90: Cap. (Tons)	90: SDT (F)	90: kW	90: Cooler Flow Data Gpm	90: Cooler Flow Data PD
40	075	77.3	110.5	76.2	184.8	10.6	75.1	115.0	78.7	179.6	10.0	72.9	119.5	81.2	174.4	9.5
	090	91.6	110.5	90.0	219.0	14.6	89.0	114.9	92.7	212.6	13.8	86.3	119.3	95.3	206.2	13.0
	100	101.9	108.9	99.9	243.5	9.7	99.2	113.4	103.3	237.1	9.2	96.5	118.0	106.8	230.7	8.7
	110	114.2	109.7	116.2	272.9	12.1	111.1	114.2	119.9	265.5	11.5	108.0	118.7	123.6	258.2	10.9
	125	130.8	111.0	128.3	312.7	8.8	127.1	115.5	132.6	303.9	8.3	123.5	120.0	136.8	295.3	7.8
	150	160.1	110.4	153.9	382.6	8.3	155.4	114.9	159.2	371.4	7.9	150.8	119.4	164.3	360.5	7.4
	175	179.2	112.8	180.5	428.4	10.4	174.3	117.3	186.3	416.6	9.8	169.3	121.7	192.1	404.7	9.3
	200	199.3	114.9	207.0	476.4	12.7	193.8	119.3	213.5	463.2	12.1	188.4	123.7	219.9	450.3	11.4
41	075	78.8	111.1	77.0	188.5	11.0	76.6	115.6	79.5	183.3	10.4	74.4	120.0	82.1	178.0	9.8
	090	93.4	111.0	91.0	223.5	15.2	90.7	115.5	93.7	217.0	14.4	88.0	119.9	96.4	210.5	13.6
	100	103.7	109.4	100.8	247.9	10.0	101.0	113.9	104.3	241.5	9.6	98.3	118.5	107.8	235.0	9.1
	110	116.2	110.2	117.4	277.9	12.5	113.1	114.7	121.1	270.4	11.9	110.0	119.2	124.8	263.0	11.2
	125	133.3	111.6	129.6	318.8	9.1	129.6	116.0	134.0	309.9	8.6	125.9	120.5	138.3	301.1	8.1
	150	163.1	110.9	155.5	390.1	8.6	158.4	115.4	160.8	378.8	8.2	153.8	119.9	166.0	367.8	7.7
	175	182.5	113.4	182.3	436.4	10.7	177.7	117.9	188.4	425.0	10.2	172.6	122.3	194.1	412.7	9.6
	200	203.0	115.5	209.3	485.5	13.2	197.4	119.9	215.8	472.2	12.5	192.0	124.3	222.2	459.1	11.8
42	075	80.4	111.7	77.8	192.3	11.4	78.2	116.1	80.4	187.0	10.8	75.9	120.6	83.0	181.6	10.2
	090	95.3	111.6	91.9	227.9	15.8	92.6	116.1	94.7	221.5	15.0	89.8	120.4	97.4	214.8	14.1
	100	105.6	109.9	101.8	252.6	10.4	102.9	114.4	105.4	246.0	9.9	100.1	119.0	108.9	239.5	9.4
	110	118.3	110.7	118.5	283.0	13.0	115.1	115.2	122.3	275.5	12.3	112.0	119.7	126.1	267.9	11.7
	125	135.8	112.1	131.0	324.9	9.5	132.1	116.6	135.4	315.9	8.9	128.3	121.0	139.7	306.9	8.4
	150	166.3	111.5	157.0	397.7	9.0	161.5	116.0	162.5	386.4	8.5	156.8	120.4	167.8	375.1	8.0
	175	185.9	113.9	184.2	444.8	11.1	181.0	118.4	190.3	433.0	10.6	175.9	122.9	196.3	420.9	10.0
	200	206.8	116.1	211.5	494.7	13.7	201.1	120.5	218.2	481.2	13.0	195.6	124.9	224.7	468.0	12.3
43	075	81.9	112.2	78.6	196.1	11.3	79.7	116.7	81.3	190.7	11.2	77.4	121.2	83.9	185.3	10.6
	090	97.1	112.2	92.8	232.4	16.4	94.4	116.6	95.8	225.9	15.5	91.6	121.0	98.5	219.1	14.7
	100	107.5	110.4	102.8	257.2	10.8	104.7	114.9	106.4	250.6	10.3	101.9	119.5	109.9	243.9	9.7
	110	120.4	111.2	119.7	288.2	13.4	117.2	115.7	123.6	280.5	12.7	114.0	120.2	127.4	272.8	12.1
	125	138.4	112.7	132.3	331.1	9.8	134.6	117.2	136.8	322.0	9.3	130.7	121.6	141.2	312.9	8.8
	150	169.4	112.1	158.6	405.5	9.3	164.6	116.5	164.2	394.0	8.8	159.9	121.0	169.5	382.6	8.3
	175	189.5	114.6	186.2	453.6	11.6	184.4	119.0	192.3	441.3	11.0	179.3	123.5	198.4	429.0	10.4
	200	210.6	116.7	213.8	504.0	14.2	204.9	121.1	220.5	490.3	13.5	199.3	125.5	227.1	476.9	12.8
44	075	83.5	112.8	79.4	199.9	12.3	81.3	117.3	82.1	194.5	11.7	79.0	121.7	84.8	189.0	11.0
	090	99.0	112.8	93.8	236.9	17.0	96.2	117.2	96.8	230.4	16.1	93.4	121.6	99.6	223.6	15.2
	100	109.4	111.0	103.8	261.9	11.2	106.6	115.5	107.4	255.2	10.6	103.8	120.0	111.0	248.4	10.1
	110	122.5	111.8	120.8	293.3	13.9	119.3	116.3	124.8	285.6	13.2	116.1	120.8	128.7	277.9	12.5
	125	141.0	113.3	133.7	337.5	10.2	137.1	117.7	138.2	328.2	9.7	133.2	122.2	142.7	318.9	9.1
	150	172.6	112.6	160.2	413.3	9.7	167.8	117.1	165.8	401.7	9.1	162.9	121.5	171.3	390.1	8.6
	175	193.0	115.2	188.1	462.1	12.0	187.8	119.6	194.4	449.6	11.4	182.6	124.0	200.5	437.2	10.8
	200	214.4	117.4	216.1	513.4	14.7	208.7	121.8	222.9	499.5	14.0	203.0	126.2	229.6	486.0	13.2
45	075	85.1	113.4	80.2	203.8	12.8	82.8	117.9	83.0	198.3	12.1	80.5	122.3	85.7	192.8	11.5
	090	100.9	113.4	94.8	241.6	17.7	98.1	117.8	97.9	234.9	16.8	95.3	122.2	100.7	228.1	15.8
	100	111.3	111.5	104.7	266.5	11.5	108.5	116.0	108.5	259.8	11.0	105.6	120.5	112.1	253.0	10.4
	110	124.7	112.3	122.0	298.5	14.4	121.4	116.8	126.0	290.7	13.7	118.1	121.3	129.9	282.9	13.0
	125	143.6	113.9	135.1	343.8	10.6	139.7	118.3	139.6	334.4	10.0	135.7	122.7	144.1	325.0	9.5
	150	176.0	113.2	161.9	421.4	10.0	171.0	117.6	167.5	409.4	9.5	166.1	122.1	173.1	397.7	9.0
	175	196.6	115.8	190.1	470.8	12.4	191.4	120.2	196.5	458.3	11.8	186.0	124.6	202.6	445.5	11.2
	200	218.3	118.0	218.4	522.8	15.2	212.5	122.4	225.3	508.8	14.5	206.8	126.8	232.1	495.1	13.7
46	075	86.8	114.0	81.1	207.8	13.2	84.4	118.5	83.9	202.2	12.6	82.0	122.9	86.6	196.5	11.9
	090	102.8	114.0	95.8	246.2	18.3	100.0	118.4	98.9	239.5	17.4	97.1	122.8	101.8	232.6	16.4
	100	113.3	112.0	105.7	271.3	11.9	110.4	116.5	109.5	264.4	11.4	107.5	121.0	113.2	257.6	10.8
	110	126.8	112.8	123.2	303.8	14.9	123.5	117.3	127.2	295.9	14.1	120.2	121.8	131.2	288.0	13.4
	125	146.2	114.5	136.4	350.2	11.0	142.2	118.9	141.1	340.7	10.4	138.3	123.3	145.7	331.2	9.8
	150	179.3	113.8	163.5	429.4	10.4	174.2	118.2	169.3	417.2	9.8	169.3	122.7	174.8	405.4	9.3
	175	200.2	116.4	192.1	479.4	12.9	194.9	120.8	198.5	466.7	12.2	189.5	125.2	204.7	453.8	11.6
	200	222.2	118.7	220.6	532.1	15.8	216.4	123.0	227.7	518.2	15.0	210.6	127.4	234.6	504.4	14.2
47	075	88.4	114.6	81.9	211.8	13.7	86.0	119.1	84.8	206.1	13.0	83.6	123.5	87.5	200.4	12.3
	090	104.7	114.6	96.8	250.9	19.0	101.9	119.0	100.0	244.1	18.0	99.0	123.4	102.9	237.1	17.1
	100	115.2	112.5	106.7	276.0	12.4	112.3	117.0	110.5	269.2	11.8	109.4	121.5	114.3	262.2	11.2
	110	129.0	113.4	124.3	309.1	15.4	125.7	117.8	128.5	301.1	14.6	122.3	122.3	132.5	293.1	13.9
	125	148.8	115.1	137.8	356.6	11.4	144.8	119.5	142.5	347.0	10.8	140.8	123.9	147.2	337.4	10.2
	150	182.6	114.4	165.2	437.5	10.8	177.5	118.8	171.0	425.2	10.2	172.4	123.2	176.7	413.1	9.7
	175	203.7	117.0	194.1	488.2	13.3	198.3	121.4	200.5	475.1	12.7	193.0	125.9	207.0	462.5	12.0
	200	226.1	119.3	223.0	541.8	16.3	220.2	123.7	230.1	527.5	15.5	214.4	128.1	237.1	513.7	14.7
48	075	90.1	115.2	82.8	215.8	14.2	87.6	119.7	85.7	210.0	13.5	85.2	124.1	88.5	204.2	12.8
	090	106.7	115.2	97.8	255.6	19.7	103.8	119.6	101.0	248.8	18.7	100.9	124.0	104.0	241.7	17.7
	100	117.2	113.1	107.7	280.8	12.8	114.3	117.6	111.6	273.9	12.2	111.3	122.0	115.4	266.8	11.6
	110	131.2	113.9	125.5	314.5	15.9	127.8	118.4	129.7	306.4	15.1	124.5	122.9	133.8	298.3	14.3
	125	151.5	115.7	139.2	363.1	11.9	147.4	120.1	144.0	353.3	11.2	143.4	124.5	148.7	343.7	10.6
	150	186.0	115.0	166.8	445.7	11.2	180.8	119.4	172.7	433.2	10.6	175.7	123.8	178.5	421.0	10.0
	175	207.4	117.6	196.1	497.0	13.8	201.9	122.0	202.6	483.9	13.1	196.5	126.5	209.1	470.8	12.4
	200	230.1	120.0	225.4	551.5	16.9	224.1	124.3	232.5	537.1	16.1	218.2	128.7	239.6	522.9	15.2

Cap. — Capacity
kW — Compressor Motor Power Input
LCWT — Leaving Chilled Water Temperature
PD — Pressure Drop (ft of water)
SDT — Saturated Discharge Temperature

14.02
AIRC 10
Project 31

Name:______
Date:_______

Determine Latent Heat Changes Using the Latent Heat Formula

Purpose: The purpose of this project is to practice the application of the latent heat formula to determine the effect of the mass flow rate of liquids used for primary and secondary heat transfer in HVAC equipment.

Procedure: Each lab group will be assigned an air conditioning system or water chiller. The group will determine the mass flow rate of the cooling medium and then apply the latent heat formula to solve for total cooling capacity. Total cooling capacity can be found by the following formula:

$$Q = m(h_2 - h_1)$$

Where Q = net rate of heat added or removed, m = mass flow rate of the substance cooled in lb/hr, h_2-h_1 = the specific enthalpy change of the substance cooled in Btu/hr.

The mass flow rate and the specific enthalpy of water volume can be reviewed by referring to 14.02a.

Solve the following problems

1. A refrigeration unit has a cooling capacity of 327, 000 Btu/hr. Express this capacity in tons of refrigeration and in kW.

2. A water chiller with a capacity of 150 tons of refrigeration cools 320 GPM entering the chiller at 52 degrees F. At what temperature should the water leave the chiller?

3. A water chiller cools 110 GPM of water from 55 degrees to 42 degrees. Find the cooling capacity of the chiller in Btu/hr, tons of refrigeration, and kW.

REFERENCE TABLES

Table 4-1
Properties of Mixtures of Air and Saturated Water Vapor*

Table Based on Barometric Pressure of 29.92 Inches.

TEMP. F	HUMIDITY RATIO - WEIGHT OF SATURATED VAPOR PER POUND OF DRY AIR: POUNDS	GRAINS	ENTHALPY OF 1 LB. OF DRY AIR ABOVE 0 F IN BTU	ENTHALPY OF (SATURATED) VAPOR, BTU	ENTHALPY OF MIXTURE OF 1 LB. OF DRY AIR WITH VAPOR TO SATURATE IT IN BTU
0	0.000787	5.51	0.0	0.835	0.835
2	.000874	6.12	0.480	0.926	1.406
4	.000969	6.78	0.961	1.030	1.991
6	.001074	7.52	1.441	1.142	2.583
8	.001189	8.32	1.922	1.266	3.188
10	.001315	9.21	2.402	1.401	3.803
12	.001454	10.18	2.882	1.550	4.432
14	.001606	11.24	3.363	1.713	5.076
16	.001772	12.40	3.843	1.892	5.735
18	.001953	13.67	4.324	2.088	6.412
20	.002152	15.06	4.804	2.302	7.106
22	.002369	16.58	5.284	2.536	7.820
24	.002606	18.24	5.765	2.792	8.557
26	.002865	20.06	6.245	3.072	9.317
28	.003147	22.03	6.726	3.377	10.103
30	.003454	24.18	7.206	3.709	10.915
32	.003788	26.52	7.686	4.072	11.758
33	.003944	27.61	7.927	4.242	12.169
34	.004107	28.75	8.167	4.418	12.585
35	.004275	29.93	8.407	4.601	13.008
36	.004450	31.15	8.647	4.791	13.438
37	.004631	32.42	8.887	4.987	13.874
38	.004818	33.73	9.128	5.191	14.319
39	.005012	35.08	9.368	5.403	14.771
40	.005213	36.49	9.608	5.622	15.230
41	.005421	37.95	9.848	5.849	15.697
42	.005638	39.47	10.088	6.084	16.172
43	.005860	41.02	10.329	6.328	16.657
44	.006091	42.64	10.569	6.580	17.149
45	.00633	44.31	10.809	6.841	17.650
46	.00658	46.06	11.049	7.112	18.161
47	.00684	47.88	11.289	7.391	18.680
48	.00710	49.70	11.530	7.681	19.211
49	.00737	51.59	11.770	7.981	19.751
50	.00766	53.62	12.010	8.291	20.301
51	.00795	55.65	12.250	8.612	20.862
52	.00826	57.82	12.491	8.945	21.436
53	.00857	59.99	12.731	9.289	22.020
54	.00889	62.23	12.971	9.644	22.615
55	.00923	64.61	13.211	10.01	23.22
56	.00958	67.06	13.452	10.39	23.84
57	.00993	69.51	13.692	10.79	24.48
58	.01030	72.10	13.932	11.19	25.12
59	.01069	74.83	14.172	11.61	25.78
60	.01108	77.56	14.413	12.05	26.46
61	.01149	80.43	14.653	12.50	27.15
62	.01191	83.37	14.893	12.96	27.85
63	.01235	86.45	15.134	13.44	28.57
64	.01280	89.60	15.374	13.94	29.31
65	.01326	92.82	15.614	14.45	30.06
66	.01374	96.18	15.855	14.98	30.83
67	.01424	99.68	16.095	15.53	31.62
68	.01475	103.3	16.335	16.09	32.42
69	.01528	107.0	16.576	16.67	33.25
70	.01582	110.7	16.816	17.27	34.09
71	.01639	114.7	17.056	17.89	34.95
72	.01697	118.8	17.297	18.53	35.83
73	.01757	123.0	17.537	19.20	36.74
74	.01819	127.3	17.778	19.88	37.66
75	.01882	131.7	18.018	20.59	38.61
76	.01948	136.4	18.259	21.31	39.57
77	.02016	141.1	18.499	22.07	40.57
78	.02086	146.0	18.740	22.84	41.58
79	.02158	151.1	18.980	23.64	42.62
80	.02233	156.3	19.221	24.47	43.69
81	.02310	161.7	19.461	25.32	44.78
82	.02389	167.2	19.702	26.20	45.90
83	.02471	173.0	19.942	27.10	47.04
84	.02555	178.9	20.183	28.04	48.22
85	.02642	184.9	20.423	29.01	49.43
86	.02731	191.2	20.663	30.00	50.66
87	.02824	197.7	20.904	31.03	51.93
88	.02919	204.3	21.144	32.09	53.23
89	.03017	211.2	21.385	33.18	54.56
90	.03118	218.3	21.625	34.31	55.93
91	.03223	225.6	21.865	35.47	57.33
92	.03330	233.1	22.106	36.67	58.78
93	.03441	240.9	22.346	37.90	60.25
94	.03556	248.9	22.587	39.18	61.77
95	.03673	257.1	22.827	40.49	63.32
96	.03795	265.7	23.068	41.85	64.92
97	.03920	274.4	23.308	43.24	66.55
98	.04049	283.4	23.548	44.68	68.23
99	.04182	292.7	23.789	46.17	69.96
100	.04319	302.3	24.029	47.70	71.73
101	.04460	312.2	24.270	49.28	73.55
102	.04606	322.4	24.510	50.91	75.42
103	.04756	332.9	24.751	52.59	77.34
104	.04911	343.8	24.991	54.32	79.31
105	.0507	355.	25.232	56.11	81.34
106	.0523	366.	25.472	57.95	83.42
107	.0540	378.	25.713	59.85	85.56
108	.0558	391.	25.953	61.80	87.76
109	.0576	403.	26.194	63.82	90.03
110	.0594	416.	26.434	65.91	92.34
111	.0614	430.	26.675	68.05	94.72
112	.0633	443.	26.915	70.27	97.18
113	.0654	458.	27.156	72.55	99.71
114	.0675	473.	27.397	74.91	102.31
115	.0696	487.	27.637	77.34	104.98
116	.0719	503.	27.878	79.85	107.73
117	.0742	519.	28.119	82.43	110.55
118	.0765	536.	28.359	85.10	113.46
119	.0790	553.	28.600	87.86	116.46
120	.0815	570.	28.841	90.70	119.54
125	.0954	668.	30.044	106.4	136.44
130	.1116	781.	31.248	124.7	155.9
135	.1306	916.	32.452	144.4	176.9
140	.1534	1074.	33.655	172.0	205.7
145	.1803	1262.	34.859	202.5	237.4
150	.2125	1488.	36.063	239.2	275.3
155	.2514	1760.	37.267	283.5	320.8
160	.2990	2093.	38.472	337.8	376.3
165	.3581	2507.	39.677	405.3	445.0
170	.4327	3028.9	40.882	490.6	531.5
175	.5292	3704.4	42.087	601.1	643.2
180	.6578	4604.6	43.292	748.5	791.8
185	.8363	5854.1	44.498	953.2	997.7

Objective:
1. Apply algebraic equations to solve for various mechanical processes in the refrigeration cycle.
2. Determine the performance of a refrigeration system based upon the thermodynamic cycle and the mathematical language associated with it.
3. Solve basic algebraic equations used in the HVAC industry using the four basic processes of addition, subtraction, multiplication, and division.

Information Basic vocational-technical mathematics by Olivo & Olivo, Unit 56. Refrigeration principles and systems by Edward G. Pita Chapter 4.

Essential Concepts:
1. The performance of a refrigeration system is determined by examining its thermodynamic cycle.
2. The language of thermodynamics is expressed mathematically.

Structure:
To reinforce the essential concepts, the instructor will illustrate the basic formulas for the refrigeration cycle. When no further questions about the essential concepts or processes are observed, the students will be assigned two projects.

1. Solving Algebraic Equations
   Each lab group will be assigned an air conditioning or refrigeration system. After applying gages and thermometers and operating the system, the group will determine the following performance characteristics:
   - Refrigeration effect, Btu/lb of refrigerant
   - Mass flow rate of refrigerant, lb/min
   - Theoretical compressor power, hp/ton of refrigeration
   - Coefficient of Performance
   - Energy Efficiency Ratio

   This project is located at 15.01

2. Each student will submit a report comparing the difference in performance between the system assigned and the performance of a system assigned to a different group. The comparison should be based upon the data taken from the operating equipment..

Name:______
Date:_______

Project 33

Solving Algebraic Equations for Refrigeration Performance

Purpose: The purpose of this project is to express the thermodynamic cycle of a refrigeration system mathematically.

Equipment: Refrigeration gages, electronic thermometer, insulation tape, saturation chart, pressure-enthalpy diagram.

Procedure: Each lab group will be assigned an air conditioning or refrigeration system. The lab group will operate the system and record the vital signs necessary to plot the refrigeration cycle on a pressure-enthalpy diagram located at 15.01a-c.

The vital signs necessary to plot the refrigeration cycle include:

(a) Suction saturated pressure converted to temperature.
(b) Condensing saturated pressure converted to temperature.
(c) Sensible subcool temperature measured at the liquid line before the metering device.
(d) Sensible superheat temperature measured at the vapor line entering the compressor.

Based upon the recorded vital signs and how the vital signs are applied to the pressure-enthalpy diagram, each student will solve for the following operating characteristics:

(a) Refrigerating Effect in Btu/lb $\quad RE = h_c - h_a$

(b) Mass Flow Rate in lbs/min $\quad m = Q_e/RE$

(c) Theoretical Compressor Horsepower $\quad P = W \times m$

(d) Coefficient of Performance $\quad COP = RE/HC$

(e) Energy Efficiency Ratio $\quad EER = Q_e/P$

See 15.01d for the explanation of symbols

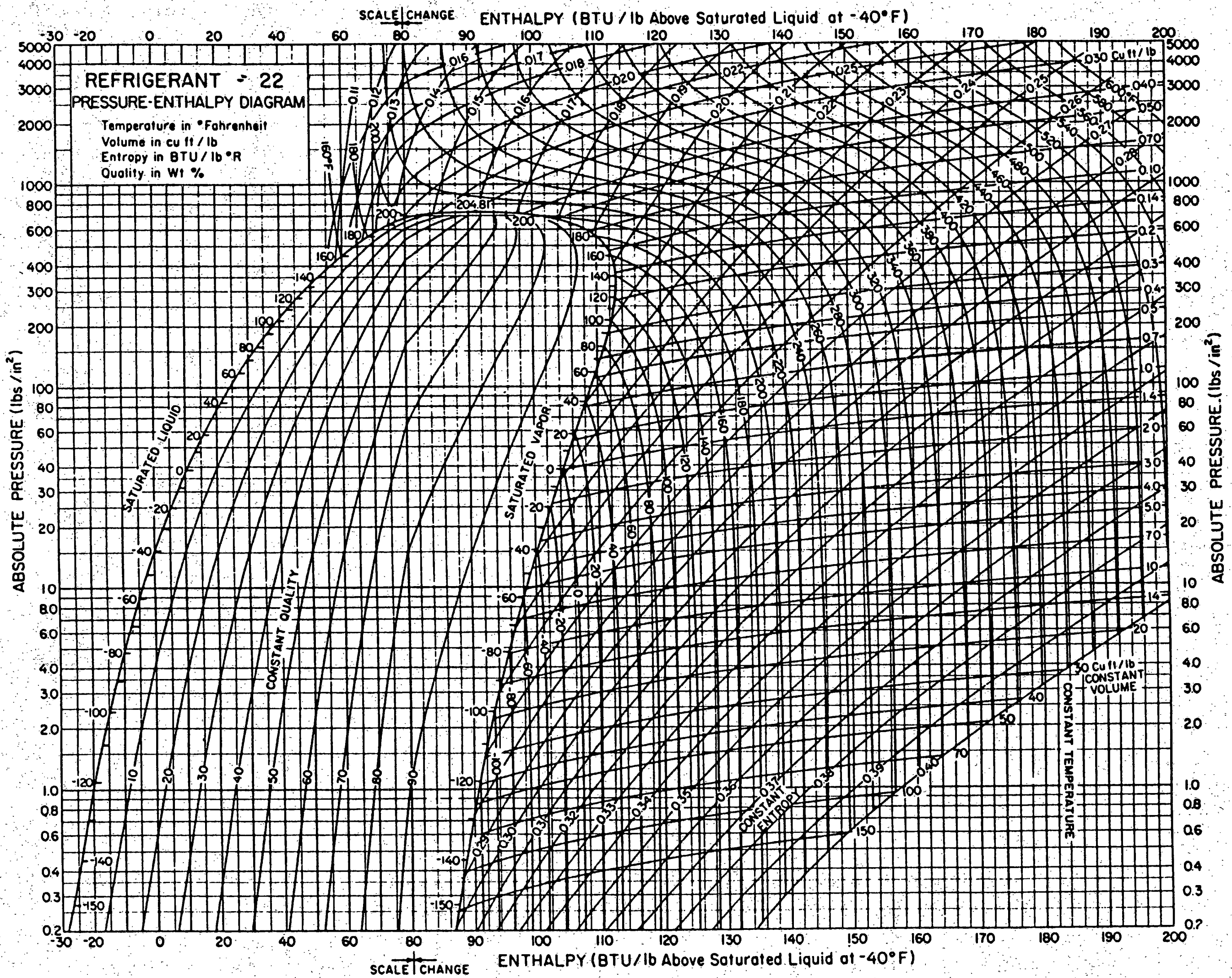


FIGURE A.3 Pressure–enthalpy diagram for Refrigerant 22 (U.S. units). (Reprinted with permission from the 1981 Fundamentals ASHRAE Handbook & Product Directory)

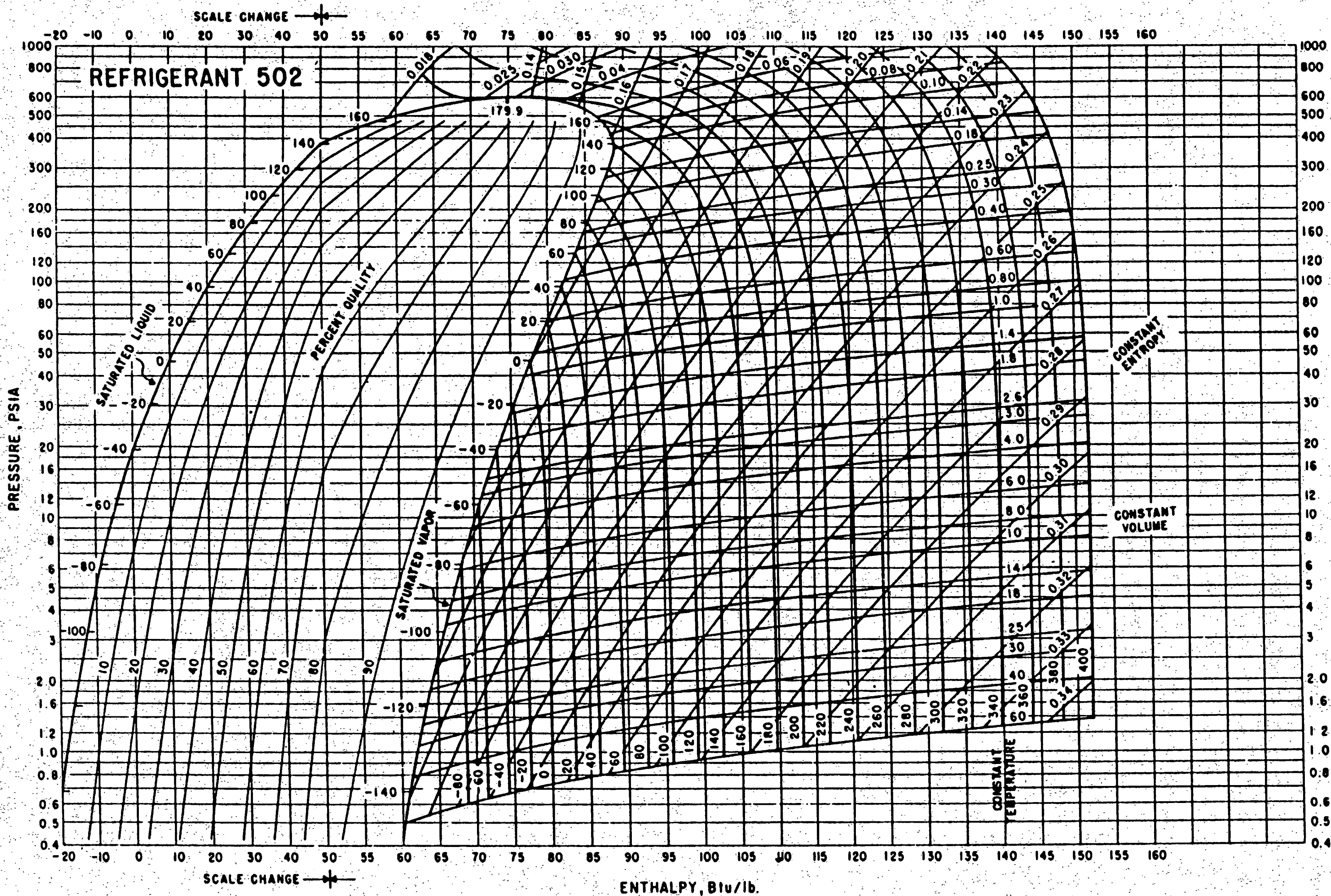


FIGURE A.4 Pressure–enthalpy diagram for Refrigerant 502 (U.S. units). (Reprinted with permission from the 1981 Fundamentals ASHRAE Handbook & Product Directory)

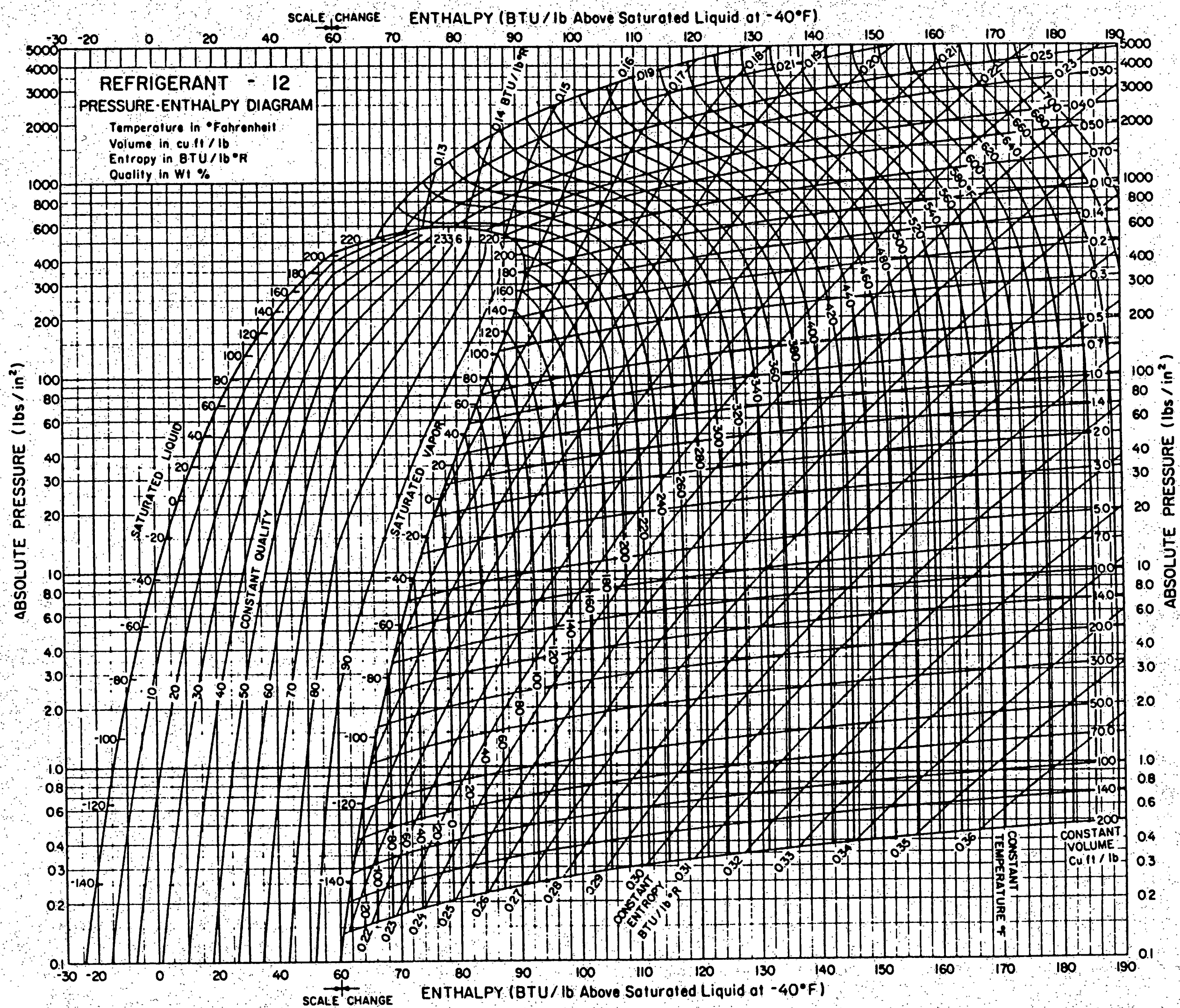


FIGURE A.2 Pressure–enthalpy diagram for Refrigerant 12 (U.S. units). (Reprinted with permission from the 1981 Fundamentals ASHRAE Handbook & Product Directory)

Objective: After successfully completing this lesson, each student should be able to:
1. Express proportion from written and physical data about two equal value ratios.
2. Calculate a missing term in a direct proportion
3. Solve practical problems in the HVAC industry for direct proportion and inverse proportion ratios.

Information: Basic vocational-technical mathematics by Olivo & Olivo, Unit 59, Electricity for air conditioning and refrigeration By E.F. Mahoney, Unit 12.

Essential Concepts:
1. Two ratios representing equal quantities are expressed as a direct proportion.
2. A proportion is indirect when the ratio varies inversely.

Structure:
The instructor will discuss the essential concepts of the lesson. To reinforce the essential concepts, the instructor will illustrate proportions based on pulleys, transformers, and the gas laws. When no further questions about the essential concepts or processes are observed, the students will be assigned three projects.

1. Direct Proportion
   Each lab group will be assigned a series of refrigerant cylinders. The group will record the temperature of each cylinder and the interior pressure and then predict the pressure when each cylinder is cooled to 32 degrees. The group submerged the cylinder in water and ice in order to check the answer. This project can be located at 16.01

2. Direct Proportion
   Each student will determine the capactiy of an evaporator coil using the rule of direct proportion applied to manufactures performance data at 16.02

3. Inverse Proportion
   Each lab group will record the pulley size and name plate RPM of a belt drive blower assembly. Based on the data, the group will develop an inverse proportion to predict the RPM of the driven pulley. This lab is located at 16.03.

Evaluation:
There are six points possible for both projects. Students who do not come prepared, do not participate, or fail to complete a project will loose two points for each project they fail to complete.

16.01
AIRC 10

Project 35

Name:______
Date:_______

Solving for Saturated Conditions by Direct Proportion

Purpose: The purpose of this project is to apply the principle of direct proportion to predict the temperature or pressure of saturated refrigerants.

Procedure: Each lab group will be assigned three refrigerant cylinders. The sensible temperature of each cylinder will be carefully recorded. Based upon the saturated tables at 16.01a-c, the lab group will predict the gage pressure within the cylinder.

Cylinder #	Temperature	Predicted psig	Actual psig
A			
B			
C			

After the predicted pressures have been recorded, the lab group will apply refrigeration gages to the cylinders and record the actualpressure.

Based upon the Perfect Gas law the lab group will predict the new gage pressure when the refrigerant cylinder temperature is reduced to 32 degrees F. The Perfect Gas law states the following:

$$p_2/p_1 = T_2/T_1$$

Where p=cylinder psia, T= absolute cylinder temperature

Cylinder #	Temperature	Predicted psig	Actual psig
A			
B			
C			

TABLE I SATURATION PROPERTIES—TEMPERATURE TABLE

TEMP. °F	PRESSURE PSIA	PRESSURE PSIG	VOLUME cu ft/lb LIQUID v_f	VOLUME cu ft/lb VAPOR v_g	DENSITY lb/cu ft LIQUID $1/v_f$	DENSITY lb/cu ft VAPOR $1/v_g$	ENTHALPY Btu/lb LIQUID h_f	ENTHALPY Btu/lb LATENT h_{fg}	ENTHALPY Btu/lb VAPOR h_g	ENTROPY Btu/(lb)(°R) LIQUID s_f	ENTROPY Btu/(lb)(°R) VAPOR s_g	TEMP. °F
15	32.415	17.719	0.011227	1.2050	89.070	0.82986	11.771	67.090	78.861	0.026243	0.16758	15
16	33.060	18.364	0.011241	1.1828	88.962	0.84544	11.989	66.977	78.966	0.026699	0.16750	16
17	33.714	19.018	0.011254	1.1611	88.854	0.86125	12.207	66.864	79.071	0.027154	0.16742	17
18	34.378	19.682	0.011268	1.1399	88.746	0.87729	12.426	66.750	79.176	0.027608	0.16734	18
19	35.052	20.356	0.011282	1.1191	88.637	0.89356	12.644	66.636	79.280	0.028062	0.16727	19
20	35.736	21.040	0.011296	1.0988	88.529	0.91006	12.863	66.522	79.385	0.028515	0.16719	20
21	36.430	21.734	0.011310	1.0790	88.419	0.92679	13.081	66.407	79.488	0.028968	0.16712	21
22	37.135	22.439	0.011324	1.0596	88.310	0.94377	13.300	66.293	79.593	0.029420	0.16704	22
23	37.849	23.153	0.011338	1.0406	88.201	0.96098	13.520	66.177	79.697	0.029871	0.16697	23
24	38.574	23.878	0.011352	1.0220	88.091	0.97843	13.739	66.061	79.800	0.030322	0.16690	24
25	39.310	24.614	0.011366	1.0039	87.981	0.99613	13.958	65.946	79.904	0.030772	0.16683	25
26	40.056	25.360	0.011380	0.98612	87.870	1.0141	14.178	65.829	80.007	0.031221	0.16676	26
27	40.813	26.117	0.011395	0.96874	87.760	1.0323	14.398	65.713	80.111	0.031670	0.16669	27
28	41.580	26.884	0.011409	0.95173	87.649	1.0507	14.618	65.596	80.214	0.032118	0.16662	28
29	42.359	27.663	0.011424	0.93509	87.537	1.0694	14.838	65.478	80.316	0.032566	0.16655	29
30	43.148	28.452	0.011438	0.91880	87.426	1.0884	15.058	65.361	80.419	0.033013	0.16648	30
31	43.948	29.252	0.011453	0.90286	87.314	1.1076	15.279	65.243	80.522	0.033460	0.16642	31
32	44.760	30.064	0.011468	0.88725	87.202	1.1271	15.500	65.124	80.624	0.033905	0.16635	32
33	45.583	30.887	0.011482	0.87197	87.090	1.1468	15.720	65.006	80.726	0.034351	0.16629	33
34	46.417	31.721	0.011497	0.85702	86.977	1.1668	15.942	64.886	80.828	0.034796	0.16622	34
35	47.263	32.567	0.011512	0.84237	86.865	1.1871	16.163	64.767	80.930	0.035240	0.16616	35
36	48.120	33.424	0.011527	0.82803	86.751	1.2077	16.384	64.647	81.031	0.035683	0.16610	36
37	48.989	34.293	0.011542	0.81399	86.638	1.2285	16.606	64.527	81.133	0.036126	0.16604	37
38	49.870	35.174	0.011557	0.80023	86.524	1.2496	16.828	64.406	81.234	0.036569	0.16598	38
39	50.763	36.067	0.011573	0.78676	86.410	1.2710	17.050	64.285	81.335	0.037011	0.16592	39
40	51.667	36.971	0.011588	0.77357	86.296	1.2927	17.273	64.163	81.436	0.037453	0.16586	40
41	52.584	37.888	0.011603	0.76064	86.181	1.3147	17.495	64.042	81.537	0.037893	0.16580	41
42	53.513	38.817	0.011619	0.74798	86.066	1.3369	17.718	63.919	81.637	0.038334	0.16574	42
43	54.454	39.758	0.011635	0.73557	85.951	1.3595	17.941	63.796	81.737	0.038774	0.16568	43
44	55.407	40.711	0.011650	0.72341	85.836	1.3823	18.164	63.673	81.837	0.039213	0.16562	44
45	56.373	41.677	0.011666	0.71149	85.720	1.4055	18.387	63.550	81.937	0.039652	0.16557	45
46	57.352	42.656	0.011582	0.69982	85.604	1.4289	18.611	63.426	82.037	0.040091	0.16551	46
47	58.343	43.647	0.011698	0.68837	85.487	1.4527	18.835	63.301	82.136	0.040529	0.16546	47
48	59.347	44.651	0.011714	0.67715	85.371	1.4768	19.059	63.177	82.236	0.040966	0.16540	48
49	60.364	45.668	0.011730	0.66616	85.254	1.5012	19.283	63.051	82.334	0.041403	0.16535	49
50	61.394	46.698	0.011746	0.65537	85.136	1.5258	19.507	62.926	82.433	0.041839	0.16530	50
51	62.437	47.741	0.011762	0.64480	85.018	1.5509	19.732	62.800	82.532	0.042276	0.16524	51
52	63.494	48.798	0.011779	0.63444	84.900	1.5762	19.957	62.673	82.630	0.042711	0.16519	52
53	64.563	49.867	0.011795	0.62428	84.782	1.6019	20.182	62.546	82.728	0.043146	0.16514	53
54	65.646	50.950	0.011811	0.61431	84.663	1.6278	20.408	62.418	82.826	0.043581	0.16509	54
55	66.743	52.047	0.011828	0.60453	84.544	1.6542	20.634	62.290	82.924	0.044015	0.16504	55
56	67.853	53.157	0.011845	0.59495	84.425	1.6808	20.859	62.162	83.021	0.044449	0.16499	56
57	68.977	54.281	0.011862	0.58554	84.305	1.7078	21.086	62.033	83.119	0.044883	0.16494	57
58	70.115	55.419	0.011879	0.57632	84.185	1.7352	21.312	61.903	83.215	0.045316	0.16489	58
59	71.267	56.571	0.011896	0.56727	84.065	1.7628	21.539	61.773	83.312	0.045748	0.16484	59
60	72.433	57.737	0.011913	0.55839	83.944	1.7909	21.766	61.643	83.409	0.046180	0.16479	60
61	73.613	58.917	0.011930	0.54967	83.823	1.8193	21.993	61.512	83.505	0.046612	0.16474	61
62	74.807	60.111	0.011947	0.54112	83.701	1.8480	22.221	61.380	83.601	0.047044	0.16470	62
63	76.016	61.320	0.011965	0.53273	83.580	1.8771	22.448	61.248	83.696	0.047475	0.16465	63
64	77.239	62.543	0.011982	0.52450	83.457	1.9066	22.676	61.116	83.792	0.047905	0.16460	64
65	78.477	63.781	0.012000	0.51642	83.335	1.9364	22.905	60.982	83.887	0.048336	0.16456	65
66	79.729	65.033	0.012017	0.50848	83.212	1.9666	23.133	60.849	83.982	0.048765	0.16451	66
67	80.996	66.300	0.012035	0.50070	83.089	1.9972	23.362	60.715	84.077	0.049195	0.16447	67
68	82.279	67.583	0.012053	0.49305	82.965	2.0282	23.591	60.580	84.171	0.049624	0.16442	68

ABLE I "FREON" 502 SATURATION PROPERTIES—TEMPERATURE TABLE

TEMP. °F	PRESSURE		VOLUME cu ft/lb		DENSITY lb/cu ft		ENTHALPY Btu/lb			ENTROPY Btu/(lb)(°R)		TEMP. °F
	PSIA	PSIG	LIQUID	VAPOR	LIQUID	VAPOR	LIQUID	LATENT	VAPOR	LIQUID	VAPOR	
15	61.225	46.529	0.011792	0.66604	84.797	1.5013	13.494	65.816	79.310	0.02997	0.16863	15
16	62.379	47.683	0.011810	0.65410	84.669	1.5288	13.756	65.660	79.416	0.03052	0.16855	16
17	63.548	48.852	0.011828	0.64241	84.540	1.5566	14.018	65.503	79.521	0.03107	0.16848	17
18	64.734	50.038	0.011846	0.63098	84.411	1.5848	14.281	65.345	79.626	0.03161	0.16841	18
19	65.936	51.240	0.011864	0.61979	84.282	1.6134	14.545	65.186	79.731	0.03216	0.16833	19
20	67.155	52.459	0.011883	0.60884	84.152	1.6424	14.809	65.026	79.836	0.03270	0.16826	20
21	68.391	53.695	0.011901	0.59812	84.022	1.6719	15.073	64.866	79.940	0.03325	0.16819	21
22	69.643	54.947	0.011920	0.58762	83.891	1.7017	15.339	64.704	80.043	0.03379	0.16812	22
23	70.913	56.217	0.011938	0.57735	83.760	1.7320	15.604	64.542	80.147	0.03434	0.16805	23
24	72.199	57.503	0.011957	0.56730	83.629	1.7627	15.871	64.379	80.250	0.03488	0.16799	24
25	73.503	58.807	0.011976	0.55745	83.497	1.7938	16.138	64.215	80.353	0.03543	0.16792	25
26	74.824	60.128	0.011995	0.54781	83.365	1.8254	16.405	64.050	80.455	0.03597	0.16785	26
27	76.163	61.467	0.012014	0.53837	83.232	1.8574	16.673	63.884	80.557	0.03652	0.16778	27
28	77.520	62.824	0.012033	0.52912	83.099	1.8898	16.941	63.717	80.659	0.03706	0.16772	28
29	78.894	64.198	0.012053	0.52007	82.966	1.9228	17.210	63.550	80.760	0.03761	0.16765	29
30	80.286	65.590	0.012072	0.51120	82.832	1.9561	17.480	63.381	80.861	0.03815	0.16759	30
31	81.697	67.001	0.012092	0.50251	82.698	1.9900	17.750	63.212	80.962	0.03870	0.16752	31
32	83.126	68.430	0.012111	0.49399	82.563	2.0242	18.020	63.042	81.062	0.03924	0.16746	32
33	84.573	69.877	0.012131	0.48565	82.428	2.0590	18.291	62.871	81.162	0.03979	0.16739	33
34	86.038	71.342	0.012151	0.47748	82.292	2.0943	18.563	62.698	81.262	0.04033	0.16733	34
35	87.522	72.826	0.012171	0.45947	82.156	2.1300	18.835	62.526	81.361	0.04087	0.16727	35
36	89.026	74.330	0.012192	0.46162	82.020	2.1662	19.107	62.352	81.460	0.04142	0.16721	36
37	90.548	75.852	0.012212	0.45393	81.883	2.2029	19.381	62.177	81.558	0.04196	0.16715	37
38	92.089	77.393	0.012233	0.44638	81.746	2.2401	19.654	62.001	81.656	0.04250	0.16708	38
39	93.649	78.953	0.012253	0.43899	81.608	2.2779	19.928	61.825	81.754	0.04305	0.16702	39
40	95.229	80.533	0.012274	0.43175	81.469	2.3161	20.203	61.647	81.851	0.04359	0.16696	40
41	96.828	82.132	0.012295	0.42464	81.330	2.3549	20.478	61.469	81.948	0.04413	0.16690	41
42	98.447	83.751	0.012316	0.41767	81.191	2.3941	20.754	61.290	82.044	0.04468	0.16684	42
43	100.08	85.38	0.012337	0.41084	81.051	2.4339	21.030	61.110	82.140	0.04522	0.16678	43
44	101.74	87.04	0.012359	0.40414	80.911	2.4743	21.307	60.928	82.235	0.04576	0.16673	44
45	103.42	88.72	0.012380	0.39757	80.770	2.5152	21.584	60.746	82.331	0.04630	0.16667	45
46	105.12	90.42	0.012402	0.39113	80.629	2.5566	21.861	60.563	82.425	0.04685	0.16661	46
47	106.84	92.14	0.012424	0.38481	80.487	2.5986	22.140	60.380	82.520	0.04739	0.16655	47
48	108.58	93.88	0.012446	0.37861	80.345	2.6412	22.418	60.195	82.613	0.04793	0.16649	48
49	110.34	95.64	0.012468	0.37252	80.202	2.6843	22.697	60.009	82.707	0.04847	0.16644	49
50	112.12	97.42	0.012490	0.36655	80.058	2.7280	22.977	59.822	82.800	0.04901	0.16638	50
51	113.92	99.22	0.012513	0.36070	79.914	2.7723	23.257	59.635	82.892	0.04955	0.16632	51
52	115.74	101.05	0.012536	0.35495	79.769	2.8172	23.538	59.446	82.984	0.05009	0.16627	52
53	117.59	102.89	0.012558	0.34931	79.624	2.8627	23.819	59.257	83.076	0.05063	0.16621	53
54	119.45	104.75	0.012581	0.34377	79.479	2.9088	24.100	59.066	83.167	0.05117	0.16616	54
55	121.34	106.64	0.012605	0.33834	79.332	2.9555	24.382	58.875	83.257	0.05171	0.16610	55
56	123.25	108.55	0.012628	0.33301	79.185	3.0028	24.665	58.682	83.347	0.05225	0.16605	56
57	125.18	110.48	0.012652	0.32777	79.038	3.0508	24.948	58.489	83.437	0.05279	0.16599	57
58	127.13	112.43	0.012675	0.32263	78.890	3.0994	25.231	58.294	83.526	0.05333	0.16594	58
59	129.10	114.41	0.012699	0.31759	78.741	3.1486	25.515	58.099	83.615	0.05387	0.16588	59
60	131.10	116.40	0.012723	0.31263	78.592	3.1985	25.799	57.903	83.703	0.05441	0.16583	60
61	133.12	118.42	0.012748	0.30777	78.441	3.2491	26.084	57.705	83.790	0.05495	0.16577	61
62	135.16	120.46	0.012772	0.30299	78.291	3.3004	26.370	57.507	83.877	0.05549	0.16572	62
63	137.22	122.53	0.012797	0.29830	78.140	3.3523	26.656	57.308	83.964	0.05602	0.16566	63
64	139.31	124.61	0.012822	0.29369	77.988	3.4049	26.942	57.107	84.050	0.05656	0.16561	64
65	141.42	126.72	0.012847	0.28916	77.835	3.4582	27.229	56.906	84.135	0.05710	0.16556	65
66	143.55	128.86	0.012872	0.28471	77.682	3.5122	27.516	56.704	84.220	0.05764	0.16550	66

TABLE I SATURATION PROPERTIES—TEMPERATURE TABLE

TEMP.	PRESSURE		VOLUME cu ft/lb		DENSITY lb/cu ft		ENTHALPY Btu/lb			ENTROPY Btu/(lb)(°R)		TEMP.
°F	PSIA	PSIG	LIQUID v_f	VAPOR v_g	LIQUID $1/v_f$	VAPOR $1/v_g$	LIQUID h_f	LATENT h_{fg}	VAPOR h_g	LIQUID s_f	VAPOR s_g	°F
15	32.415	17.719	0.011227	1.2050	89.070	0.82986	11.771	67.090	78.861	0.026243	0.16758	15
16	33.060	18.364	0.011241	1.1828	88.962	0.84544	11.989	66.977	78.966	0.026699	0.16750	16
17	33.714	19.018	0.011254	1.1611	88.854	0.86125	12.207	66.864	79.071	0.027154	0.16742	17
18	34.378	19.682	0.011268	1.1399	88.746	0.87729	12.426	66.750	79.176	0.027608	0.16734	18
19	35.052	20.356	0.011282	1.1191	88.637	0.89356	12.644	66.636	79.280	0.028062	0.16727	19
20	35.736	21.040	0.011296	1.0988	89.529	0.91006	12.863	66.522	79.385	0.028515	0.16719	20
21	36.430	21.734	0.011310	1.0790	88.419	0.92679	13.081	66.407	79.488	0.028968	0.16712	21
22	37.135	22.439	0.011324	1.0596	88.310	0.94377	13.300	66.293	79.593	0.029420	0.16704	22
23	37.849	23.153	0.011338	1.0406	88.201	0.96098	13.520	66.177	79.697	0.029871	0.16697	23
24	38.574	23.878	0.011352	1.0220	88.091	0.97843	13.739	66.061	79.800	0.030322	0.16690	24
25	39.310	24.614	0.011366	1.0039	87.981	0.99613	13.958	65.946	79.904	0.030772	0.16683	25
26	40.056	25.360	0.011380	0.98612	87.870	1.0141	14.178	65.829	80.007	0.031221	0.16676	26
27	40.813	26.117	0.011395	0.96874	87.760	1.0323	14.398	65.713	80.111	0.031670	0.16669	27
28	41.580	26.884	0.011409	0.95173	87.649	1.0507	14.618	65.596	80.214	0.032118	0.16662	28
29	42.359	27.663	0.011424	0.93509	87.537	1.0694	14.838	65.478	80.316	0.032566	0.16655	29
30	43.148	28.452	0.011438	0.91880	87.426	1.0884	15.058	65.361	80.419	0.033013	0.16648	30
31	43.948	29.252	0.011453	0.90286	87.314	1.1076	15.279	65.243	80.522	0.033460	0.16642	31
32	44.760	30.064	0.011468	0.88725	87.202	1.1271	15.500	65.124	80.624	0.033905	0.16635	32
33	45.583	30.887	0.011482	0.87197	87.090	1.1468	15.720	65.006	80.726	0.034351	0.16629	33
34	46.417	31.721	0.011497	0.85702	86.977	1.1668	15.942	64.886	80.828	0.034796	0.16622	34
35	47.263	32.567	0.011512	0.84237	86.865	1.1871	16.163	64.767	80.930	0.035240	0.16616	35
36	48.120	33.424	0.011527	0.82803	86.751	1.2077	16.384	64.647	81.031	0.035683	0.16610	36
37	48.989	34.293	0.011542	0.81399	86.638	1.2285	16.606	64.527	81.133	0.036126	0.16604	37
38	49.870	35.174	0.011557	0.80023	86.524	1.2496	16.828	64.406	81.234	0.036569	0.16598	38
39	50.763	36.067	0.011573	0.78676	86.410	1.2710	17.050	64.285	81.335	0.037011	0.16592	39
40	51.667	36.971	0.011588	0.77357	86.296	1.2927	17.273	64.163	81.436	0.037453	0.16586	40
41	52.584	37.888	0.011603	0.76064	86.181	1.3147	17.495	64.042	81.537	0.037893	0.16580	41
42	53.513	38.817	0.011619	0.74798	86.066	1.3369	17.718	63.919	81.637	0.038334	0.16574	42
43	54.454	39.758	0.011635	0.73557	85.951	1.3595	17.941	63.796	81.737	0.038774	0.16568	43
44	55.407	40.711	0.011650	0.72341	85.836	1.3823	18.164	63.673	81.837	0.039213	0.16562	44
45	56.373	41.677	0.011666	0.71149	85.720	1.4055	18.387	63.550	81.937	0.039652	0.16557	45
46	57.352	42.656	0.011682	0.69982	85.604	1.4289	18.611	63.426	82.037	0.040091	0.16551	46
47	58.343	43.647	0.011698	0.68837	85.487	1.4527	18.835	63.301	82.136	0.040529	0.16546	47
48	59.347	44.651	0.011714	0.67715	85.371	1.4768	19.059	63.177	82.236	0.040966	0.16540	48
49	60.364	45.668	0.011730	0.66616	85.254	1.5012	19.283	63.051	82.334	0.041403	0.16535	49
50	61.394	46.698	0.011746	0.65537	85.136	1.5258	19.507	62.926	82.433	0.041839	0.16530	50
51	62.437	47.741	0.011762	0.64480	85.018	1.5509	19.732	62.800	82.532	0.042276	0.16524	51
52	63.494	48.798	0.011779	0.63444	84.900	1.5762	19.957	62.673	82.630	0.042711	0.16519	52
53	64.563	49.867	0.011795	0.62428	84.782	1.6019	20.182	62.546	82.728	0.043146	0.16514	53
54	65.646	50.950	0.011811	0.61431	84.663	1.6278	20.408	62.418	82.826	0.043581	0.16509	54
55	66.743	52.047	0.011828	0.60453	84.544	1.6542	20.634	62.290	82.924	0.044015	0.16504	55
56	67.853	53.157	0.011845	0.59495	84.425	1.6808	20.859	62.162	83.021	0.044449	0.16499	56
57	68.977	54.281	0.011862	0.58554	84.305	1.7078	21.086	62.033	83.119	0.044883	0.16494	57
58	70.115	55.419	0.011879	0.57632	84.185	1.7352	21.312	61.903	83.215	0.045316	0.16489	58
59	71.267	56.571	0.011896	0.56727	84.065	1.7628	21.539	61.773	83.312	0.045748	0.16484	59
60	72.433	57.737	0.011913	0.55839	83.944	1.7909	21.766	61.643	83.409	0.046180	0.16479	60
61	73.613	58.917	0.011930	0.54967	83.823	1.8193	21.993	61.512	83.505	0.046612	0.16474	61
62	74.807	60.111	0.011947	0.54112	83.701	1.8480	22.221	61.380	83.601	0.047044	0.16470	62
63	76.016	61.320	0.011965	0.53273	83.580	1.8771	22.448	61.248	83.696	0.047475	0.16465	63
64	77.239	62.543	0.011982	0.52450	83.457	1.9066	22.676	61.116	83.792	0.047905	0.16460	64
65	78.477	63.781	0.012000	0.51642	83.335	1.9364	22.905	60.982	83.887	0.048336	0.16456	65
66	79.729	65.033	0.012017	0.50848	83.212	1.9666	23.133	60.849	83.982	0.048765	0.16451	66
67	80.996	66.300	0.012035	0.50070	83.089	1.9972	23.362	60.715	84.077	0.049195	0.16447	67
68	82.279	67.583	0.012053	0.49305	82.965	2.0282	23.591	60.580	84.171	0.049624	0.16442	68
69	83.576	68.880	0.012071	0.48555	82.841	2.0595	23.821	60.445	84.266	0.050053	0.16438	69
70	84.888	70.192	0.012089	0.47818	82.717	2.0913	24.050	60.309	84.359	0.050482	0.16434	70

16.02
AIRC 10
Project 36

Name:______
Date:_______

Solving for Evaporator Capacity by Direct Proportion

Purpose: The purpose of this project is to apply the principle of direct proportion in order to predict the capacity of an evaporator coil used in medium temperature applications.

Procedure: Each student will refer to the performance data for evaporators at 16.02a-b. Based upon the performance data and the information at 07.03b, each student will determine the capacity of the evaporator given the new temperature difference between suction saturation temperature and fixture temperature.

The capacity of an evaporator coil and condensing coil is based on the following consistency:

$$Q_e = U \times A \times TD$$

Where Qe=capacity of the evaporator coil, U=heat transfer coefficient of the coil, A=area of the coil, and TD= temperature difference between the evaporator coil and the fixture temperature.

The student will predict the new evaporator capacity based upon the following proportional consistency:

$$Q_{e2}/TD_2 = Q_{e1}/TD_1$$

Where: Qe=capacity of the evaporator coil, TD= temperature difference between the evaporator coil and the fixture temperature

Evaporator coil	TD Coil & Fixture	Capacity in Btu/hr	Capacity in tons
UAH1 - 232	15		
UAH3 - 648	20		
UAH2 - 365	12		
UAH4 - 980		147,000	
UAH2 - 433		60,200	
UAH! - 232		46,400	
UAH4 - 1100		132,000	

SELECTION AND APPLICATION TABLES FOR RUSSELL RUSS PAK SYSTEMS

Tables on the following pages contain capacity and balance data for the Russ Pak systems. They are intended to cover the normal range of conditions with various system selections of recommended equipment.

When special applications arise which are not covered by the Russ Pak system listed here, consult factory for prices.

All system capacities are based on 90° F Ambient. Increase (decrease) capacity by 6% for each 10° F lower (higher) ambient temperatures.

MODEL NUMBER NOMENCLATURE

RP H 20 2—FL46-265(4)

- (4) — No. of evaporators
- FL46-265 — Model number of evaporator (See pages 2 and 3 for description)
- 2 — Refrigerant: 1 = R12, 2 = R-22, 5 = R502
- 20 — Compressor HP
- H — Condensing Unit Temp. Range: H = High, M = Medium, L = Low
- RP — Russ Pak Complete Refrigeration System Designation

55° Cutting Room

HP	Ref.	BTUH	Evap. T.D.	System Model # **
3	12	32.000	18	RPH31-FL46-180
5	22	55.000	20	RPH52-FL46-265
7½	22	78.000	21	RPH82-FL46-180(2)
10	22	109.500	20	RPH102-FL46-265(2)
15	22	147.000	18	RPH152-FL46-265(3)
20	22	182.500	17	RPH202-FL46-265(4)

55° Storage Room - AL Evaporators

HP	Ref.	BTUH	Evap. T.D.	System Model # **
3	12	31.000	19	RPH31-AL38-156
5	22	55.000	21	RPH52-AL58-260
5	22	57.000	18	RPH52-AL38-156(2)
7½	22	81.000	20	RPH82-AL48-208(2)

55° Storage Room—UA Evaporators

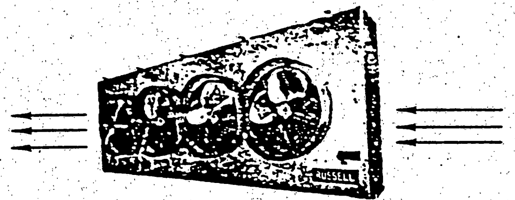
HP	Ref.	BTUH	Evap. T.D.	System Model # **
7½	22	82.500	19	RPH82-UAH2-433
10	22	109.500	22	RPH102-UAH2-490
10	22	115.000	18	RPH102-UAM2-329(2)
15	22	144.500	20	RPH152-UAH3-736
15	22	144.000	20	RPH152-UAH2-365(2)
20	22	167.000	22	RPH202-UAH4-980
20	22	173.000	20	RPH202-UAH2-433(2)

50° Storage Room - Low Velocity - FL Evap.

HP	Ref.	BTUH	Evap. T.D.	System Model # **
3	12	29.000	16	RPH31-FL46-180
5	22	51.000	19	RPH52-FL46-265
7½	22	71.000	20	RPH82-FL46-180(2)
10	22	103.000	19	RPH102-FL46-265(2)
15	22	140.000	17	RPH152-FL46-265(3)
20	22	172.000	16	RPH202-FL46-265(4)

RUSS PAK — COMPLETE REFRIGERATION SYSTEMS WITH LIST PRICES — RP MAY 1983

UT
ULTRA TEMP
ULTRA HIGH POWERED UNIT COOLERS



Russell's new Ultra Temp unit cooler is exceptionally versatile, covering all temperature applications in a compact, slim profile design. The Ultra Temp is ideally suited for large walk-ins, storage and freezers. Air throw is upto 100 feet with optional metal air straighteners.

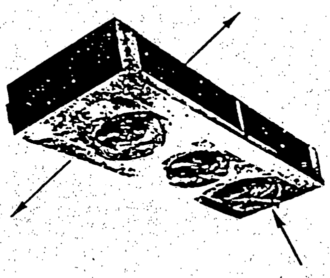
Low Temperature Models
With Electric Defrost

Model	BTU/HR 10° TD	BTU/HR 12° TD	Fan Dia.	Motor H.P.	W	H	D	WL
4 Fins per inch -30° Evap Temperature—Electric or Hot-Gas Defrost								
U•U1-118	11,800	14,200	20	3/4	46½	25½	21¼	190
U•U2-236	23,600	28,300	20	3/4	76½	25½	21¼	370
U•U2-355	35,500	42,600	20	3/4	76½	31½	21¼	440
U•U3-474	47,400	56,900	20	3/4	106½	31½	21¼	570
U•U4-711	71,100	85,300	20	3/4	136½	31½	21¼	665
U•U4-851	85,100	102,100	24	3/4	136½	49½	23¾	875
U•U4-1080	108,000	129,600	24	3/4	136½	49½	23¾	900
6 Fins per inch -10° Evap Temperature—Electric or Hot-Gas Defrost								
U•L1-152	15,200	18,200	20	3/4	46½	25½	21¼	200
U•L1-193	19,300	23,200	20	3/4	46½	25½	21¼	220
U•L2-304	30,400	36,500	20	3/4	76½	25½	21¼	400
U•L2-361	36,100	43,300	20	3/4	76½	31½	21¼	425
U•L2-408	40,800	49,000	20	3/4	76½	31½	21¼	446
U•L3-540	54,000	64,800	20	3/4	106½	31½	21¼	585
U•L3-613	61,300	73,600	20	3/4	106½	31½	21¼	620
U•L4-722	72,200	86,600	20	3/4	136½	31½	21¼	675
U•L4-817	81,700	98,000	20	3/4	136½	31½	21¼	726
U•L4-1100	110,000	132,000	24	3/4	136½	49½	23¾	885
U•L4-1380	138,000	165,600	24	3/4	136½	49½	23¾	910

Air Defrost Models

Model	BTU/HR 10° TD	BTU/HR 15° TD	Fan Dia.	Motor H.P.	W	H	D	WL
6 Fins per inch +25° Evap Temperature—Air Defrost								
UAM1-164	16,400	24,600	20	1/3	46½	25½	21¼	200
UAM1-209	20,900	31,350	20	1/3	46½	25½	21¼	220
UAM2-329	32,900	49,350	20	1/3	76½	31½	21¼	400
UAM2-390	39,000	58,500	20	1/3	76½	31½	21¼	425
UAM2-441	44,100	66,150	20	1/3	76½	31½	21¼	446
UAM3-583	58,300	87,450	20	1/3	106½	31½	21¼	585
UAM3-662	66,200	99,300	20	1/3	106½	31½	21¼	620
UAM4-780	78,000	117,000	20	1/3	136½	31½	21¼	675
UAM4-882	88,200	132,300	20	1/3	136½	31½	21¼	726
UAM4-1320	132,000	198,000	24	3/4	136½	49½	23¾	885
UAM4-1656	165,600	248,400	24	3/4	136½	49½	23¾	910
8 Fins per inch +25° Evap Temperature—Air Defrost								
UAH1-182	18,200	27,300	20	1/3	46½	25½	21¼	210
UAH1-232	23,200	34,800	20	1/3	46½	25½	21¼	230
UAH2-365	36,500	54,750	20	1/3	76½	31½	21¼	410
UAH2-433	43,300	64,950	20	1/3	76½	31½	21¼	435
UAH2-490	49,000	73,500	20	1/3	76½	31½	21¼	458
UAH3-648	64,800	97,200	20	1/3	106½	31½	21¼	600
UAH3-736	73,600	110,400	20	1/3	106½	31½	21¼	635
UAH4-866	86,600	129,900	20	1/3	136½	31½	21¼	690
UAH4-980	98,000	147,000	20	1/3	136½	31½	21¼	746
UAH4-1452	145,200	217,800	24	3/4	136½	49½	23¾	805
UAH4-1821	182,100	273,150	24	3/4	136½	49½	23¾	930

FL
FLOW-TEMP
LOW VELOCITY UNIT COOLERS



Model	BTU/HR. 10° TD	BTU/HR. 12° TD	Fans No. — Diam.	Fan Motor H.P.	Dimensions D	W	H	WL
FL26-67	6,700	8,040	2-10	9W	27½	58½	8½	100
FL36-100	10,000	12,000	3-10	9W	27½	82½	9	160
FL36-135	13,500	16,200	3-10	16W	27½	82½	12	207
FL46-180	18,000	21,600	4-10	16W	27½	106½	12	291
FL46-265	26,500	31,800	4-10	16W	27½	106½	15	320

The Russell Flow Temp Unit Cooler was first introduced to the refrigeration industry in 1964 to answer the many requests for reduced velocity applications. It is especially designed for high humidity applications where meat shrinkage in cutting and storage rooms is a factor. It has an extremely comfortable sound level. Thousands have been in use in meat cutting, holding and packaging rooms, fruit and vegetable storage rooms and florist boxes. Flow-Temps come with a white baked polyester coating on the housing.

All of the above Unit Coolers are UL listed and are made for standard air defrost as well as electric defrost.

TESTING:

Each Russ Pak system is assembled under strict quality control. The condensing unit is pressurized for leak detection, then fully evacuated to 200 microns pressure. The electrical circuit is given a full dielectric test prior to the unit being given a complete run test. The unit is prepared for shipment with a holding charge of dry nitrogen.

16.03
AIRC 10

Project 37

Name:______
Date:_______

Solving for Blower RPM Based on Inverse Proportion

Purpose: The purpose of this project is to apply the principle of inverse proportion in order to predict the RPM of a blower fan in an air distribution system.

Procedure: Each lab group will record the pulley sizes and name plate rotations per minute (RPM) of the motor on a belt drive blower assembly. Based on the data, the group will determine the RPM of the driven pulley from the inverse proportion:

$$D_b/D_a = RPM_a/RPM_b$$

Where Da=the diameter of pulley A, Db=the diameter of pulley B, RPMa= the Rotations per minute of pulley A, and RPMb= the rotations per minute of pulley B

Name plate RPM	Diameter Pulley A	Diameter Pulley B	Predicted RPM Pulley B	Actual RPM Pulley B
1725	5"	10"		
1725	7"	10"		
1725	3"	10"		
3450	5"	10"		
3450	5"	8"		

Objective: After successfully completing this lesson, each student should be able to:
1. Apply proportions to solutions for air distribution problems
2. Interpret the functions of exponents
3. Solve air side HVAC problems that require the multiplication of numbers in exponential form.

Information: Basic vocational-technical mathematics by Olivo & Olivo, Unit 64

Essential Concepts:
1. Blower RPM and air volume vary directly
2. Horse-power requirements for an electric motor increase exponentially per unit increase of blower RPM.
3. A simplified method of stating that a quantity is to be multiplied by itself many times is to write the number in exponential form.

Structure:
The instructor will discuss the essential concepts of the lesson. To reinforce the essential concepts, the instructor will illustrate proportions based on the fan laws. When no further questions about the essential concepts or processes are observed, the students will be assigned two projects

1. Solving for Air Volume and Motor Horse-power Requirements
   Each lab group will be assigned an air handling unit with a belt drive blower. The group will check out the necessary instrumentation and measure the air volume traveling through the duct work. Once the volume is determined the group will be asked to increase or decrease the volume by a percentage. The solution will require determining new pulley diameters and proving the horse-power capacity is sufficient to meet the new air volume. This project is located at 17.01

Evaluation:
There are six points possible for both projects. Each student completing the projects will receive full credit. Students who do not come prepared, do not participate, or fail to complete a project will loose two points for each project they fail to complete.

17.01
AIRC 10

Project 38

Name:______
Date:_______

Solving for Air Volume and Motor Horse-Power

Purpose: The purpose of this project is to apply the principle of inverse proportion in order to solve for RPM of a blower fan in an air distribution system and predict horse-power requirements

Procedure: Each lab group will be assigned an air handling unit with a belt drive blower assembly. The group will check out the necessary instrumentation and measure the air volume traveling through the duct work.

Once the volume of air flow is determined, the group will be asked to increase or decrease the volume by a percentage. The rule for adjusting air volume through a duct is as follows:

$$RPM_{B1}/RPM_{B2} = CFM_1/CFM_2$$

Where: RPM_{B1}=original RPM of pulley B, RPM_{B2}=required RPM of pulley B, CFM_1=original air volume, and CFM_2=desired air volume

Referring to project 38, the diameter of pulley A can be adjusted to achieve the new RPM of pulley B.

$$D_b/D_a = RPM_a/RPM_b$$

Where: Da=the diameter of pulley A, Db=the diameter of pulley B, RPMa= the Rotations per minute of pulley A, and RPMb= the rotations per minute of pulley B

Horse-power requirements (hp) must me checked any time the RPM of blower is adjusted. The relationship between RPM and hp requirements is:

$$hp_2 = hp_1 \times (RPM_{B2}/RPM_{B1})^3$$

Where: hp_1=original horse-power, hp_2=new horse-power requirements, RPM_{B1}=original RPM of pulley B, RPM_{B2}=required RPM of pulley B

	RPM_a	RPM_b	Dia_a	Dia_b	CFM	hp
Existing						
New						

APPENDIX B

MT. SAN ANTONIO COLLEGE

1100 NORTH GRAND AVENUE
WALNUT, CA 91789-1399

1946-1996 50 YEAR JUBILEE

January 15, 1996

Dr. Allen D. Truell
M.A. Program Coordinator
Department of Secondary and Vocational Education
California State University San Bernardino
5500 University Parkway
San Bernardino, CA.

Dear Dr. Truell,

The Office of Instructional Services at Mount San Antonio College solidly supports Mr. Darrow Soares in developing his masters project to integrate mathematics with air conditioning and refrigeration.

In discussing the project with Mr. Soares, it is clear that the curriculum he proposes will enhance the relevance of his program to the workplace. The instructional strategies he offers will improve critical thinking, problem solving, and academic skill attainment.

The College goal for 1996-1997 is to have the curriculum for targeted programs include the integration of academic and career education as well as the inclusion of program strategies that reflect workforce needs. Since Mr. Soares' department falls into the targeted category of Engineering and Related Technologies, his project will be very relevant to the goals of the college and our community.

I look foreword to working with Mr. Soares on this project

Sincerely,

Ms. Barbara Crane
Dean of Instructional Services
Mount San Antonio College

(909) 594-5611 • FAX (909) 594-7661

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