Here is some potentially useful information:

- Air Density (approximate): 1.2 kg/m^3
- Air heat capacity (approximate): 1000 joules/kg K
- 3.28 ft = 1 m

1.4. **Savings from Using CFL Bulbs** Compact Fluorescent Light (CFL) bulbs have been available for years; they are very efficient, but a little pricey. A CFL bulb that puts out as much light as a 60W incandescent bulb might cost $10, compared to about $1 for the incandescent bulb. But CFL bulbs are expected to last (on average) 15,000 hours, compared to about 1000 hours for an incandescent bulb. So it is easy to see that you would need 15 incandescent bulbs (total cost $15) to last the 15,000 hours that you would get from one ($10) CFL bulb; you save $5 and a lot of climbing ladders to replace all those incandescent bulbs.

But there's more. A CFL bulb that puts out as much light as a 60W incandescent bulb will use about 13W or power. According to the US Energy Information Administration (www.eia.doe.gov), residential electricity costs average about $0.10 per kilowatt · hour. (1 kw · hr = 3600 kW · sec = 3600 kJ.) Over the 15,000 hours that one CFL bulb is expected to last, how much will you save on power if you replace an incandescent bulb in your home with a CFL bulb?

Develop an Excel worksheet something like the one shown in Figure 1.P4 to find the answer.

	A	B	C	D	E	F	G
1	**Savings from One CFL Bulb**						
2				**CFL Bulb**	**Incand. Bulb**		
3			Power Consumption:	13	60	W	
4			On Time:	15000	15000	hours	
5			Cost of Electricity:	$ 0.10	$ 0.10	kw-hr	
6			Total Energy Cost:			(dollars)	
7							
8			Savings:		(dollars)		
9							

Figure 1.P4
Savings by replacing one incandescent bulb with a CFL bulb.

1.5. **Comparing Cell Phone Services** Anna is thinking of changing her cell phone service, and she is comparing three plans:

1. Plan 1 has a $20/month access fee, unlimited nights and weekends, 300 anytime minutes plus $0.29/minute for minutes over 300, a text message cost of $0.10 each, and roaming costs $0.39/minute whenever she leaves the state.
2. Plan 2 has a $40/month access fee, unlimited nights and weekends, 750 anytime minutes plus $0.29/minute for minutes over 750, a text message cost of $0.05 each, and roaming costs $0.39/minute whenever she leaves the state.
3. Plan 3 has a $60/month access fee, unlimited nights and weekends, 1500 anytime minutes plus $0.19/minute for minutes over 1500, text messages are included in the anytime minutes (1 minute per message), and roaming is free.

	Anna's Expectation	Allowed Free	Paid	Cost each	Total Cost	
Comparing Cell Phone Plans						
PLAN 1						
Night and Weekend Minutes:	400	UNLIMITED	0	$ -	$ -	
Anytime Minutes:	500	300	200	$ 0.29	$ 58.00	
Text Messages:	370	0	370	$ 0.10	$ 37.00	
Roaming Minutes:	150	0	150	$ 0.39	$ 58.50	
Access Fee:					$ 20.00	
			PLAN 1 TOTAL COST:		$ 173.50	per month
PLAN 2						
Night and Weekend Minutes:						
Anytime Minutes:						
Text Messages:						
Roaming Minutes:						
Access Fee:						
			PLAN 2 TOTAL COST:			per month
PLAN 3						
Night and Weekend Minutes:						
Anytime Minutes:						
Text Messages:						
Roaming Minutes:						
Access Fee:						
			PLAN 2 TOTAL COST:			per month

AVG SOLN / CFL / CFL SOLN / Anna / Anna SOLN

Figure 1.P5
Comparing expected costs of cell phone plans.

Her primary concern is during the summer when she is away from college, out of the cell phone company's state, and spending a lot of time communicating with her friends. Looking at her bills from last summer, and trying to predict what will likely happen this summer, she anticipates the following monthly cell phone usage during the summer months:

- 400 minutes nights and weekends
- 500 anytime minutes
- 370 text messages
- 150 roaming minutes

Develop an Excel worksheet something like the one shown in Figure 1.P5 to determine which plan is the best for Anna.

- Accounting format on all dollar amounts
- Percentage format on the APR and periodic interest rate
- For column headings,
  - Text wrapping
  - Bold font
  - Centered headings
  - Heavy bottom border

Use your amortization table to determine the following:

(a) Total amount paid on the loan.
(b) Amount paid on interest.

2.2. Paying Back Student Loans II The minimum monthly payment on the loan described in Problem 2.1 was $222.04, but there is (usually) no penalty for overpayment. Recalculate the loan amortization table assuming a monthly payment of $250.

(a) How many months would it take to pay off the loan with the higher payment?
(b) What is the total amount paid on the loan?
(c) What percent of the total paid went towards interest?

2.3. Distances between European Capitals Perform an Internet search on "Travel Distances Between European Cities" and use the results to complete the grid shown in Figure 2.P3.

	A	B	C	D	E	F	G	H	I	J
1	Distances Between European Capitals (KM)									
2										
3			Athens	Berlin	Bucharest	Copenhagen	London	Madrid	Rome	
4		Athens	0							
5		Berlin		0						
6		Bucharest			0				1140	
7		Copenhagen				0				
8		London					0			
9		Madrid						0		
10		Rome			1140				0	
11										

Figure 2.P3 Distances between European capitals.

Be sure to include the following formatting features in your worksheet:

- A large, bold title.
- A border around the distances grid.
- Centering for all headings and distance values.
- Adjust column widths to fit all headings.

2.4. Exponential Growth I There is a legend that the inventor of chess asked for a small payment in return for the marvelous game he had developed: one grain of rice for the first square on the chess board, two for the second square, four for the third square and so on. There are 64 squares on a chess board.

(a) How many grains of rice were placed on the 16th square?
(b) How many grains of rice were placed on the 64th square?
(c) How many grains of rice were placed on the chess board?

This problem is intended to give you some practice working with very large numbers in Excel. You may want to try using the Scientific format. Creating a series of values from 1 to 64 for the "square number" column is a good place to use the Fill Handle.

PROBLEMS

4.1. **Trigonometric Functions** Devise a test to demonstrate the validity of the following common trigonometric formulas. What values of A and B should be used to test these functions thoroughly?

(a) $\sin(A + B) = \sin(A)\cos(B) + \cos(A)\sin(B)$
(b) $\sin(2A) = 2\sin(A)\cos(A)$
(c) $\sin^2(A) = \frac{1}{2} - \frac{1}{2}\cos(2A)$

Note: In Excel, $\sin^2(A)$ should be entered as `=(sin(A))^2`. This causes sin(A) to be evaluated first and the result to be squared.

4.2. **Basic Fluid Flow** A commonly used rule of thumb is that the average velocity in a pipe should be about 1 m/s or less for "thin" fluids (viscosity about water). If a pipe needs to deliver 6,000 m^3 of water per day, what diameter is required to satisfy the 1-m/s rule?

4.3. **Projectile Motion II** Sports programs' "shot of the day" segments sometimes show across-the-court baskets made just as (or after) the final buzzer sounds. If a basketball player, with 3 seconds remaining in the game, throws the ball at a 45° angle from 4 feet off the ground, standing 70 feet from the basket, which is 10 feet in the air, as illustrated in Figure 4.P3.

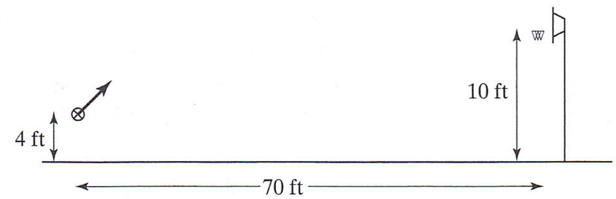

Figure 4.P3
Throwing a basketball.

(a) What initial velocity does the ball need to have in order to reach the basket?
(b) What is the time of flight?
(c) How much time will be left in the game after the shot?

Ignore air resistance in this problem.

4.4. **Pulley I** A 200-kg mass is hanging from a hook connected to a pulley, as shown in the accompanying figure. The cord around the pulley is connected to the overhead support at two points as illustrated in Figure 4.P4.

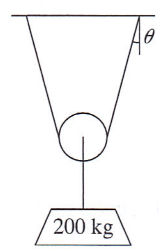

Figure 4.P4
Pulley supports.

What is the tension in each cord connected to the support if the angle of the cord from vertical is

(a) 0°?
(b) 5°?
(c) 15°?

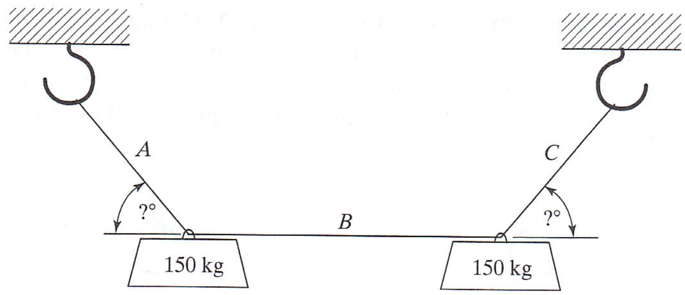

Figure 4.P7
Forces and tensions in wires, III.

If the hooks are pulled apart until the tension in wire B is 2000 N, compute

(a) the angle between the horizontal and wire C.
(b) the tension in wire C.

How does the angle in part (a) change if the tension in wire B is increased to 3000 N?

4.8. Finding the Volume of a Storage Bin I A fairly common shape for a dry-solids storage bin is a cylindrical silo with a conical collecting section at the base where the product is removed. (See Figure 4.P8.)

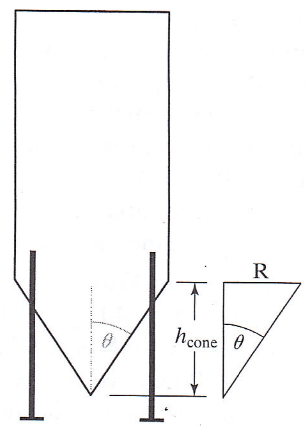

Figure 4.P8
Storage silo.

To calculate the volume of the contents, you use the formula for a cone, as long as the height of product, h, is less than the height of the conical section, h_{cone}:

$$V = \frac{1}{3}\pi r_h^2 h \qquad \text{if } h < h_{cone}. \tag{4.11}$$

Here, r_h is the radius at height h and can be calculated from h by trigonometry:

$$r_h = h_{cone} \tan(\theta). \tag{4.12}$$

If the height of the stored product is greater than the height of the conical section, the equation for a cylinder must be added to the volume of the cone:

$$V = \frac{1}{3}\pi R^2 h_{cone} + \pi R^2 (h - h_{cone}) \qquad \text{if } h > h_{cone}. \tag{4.13}$$

If the height of the conical section is 3 m, the radius of the cylindrical section is 2 m, and the total height of the storage bin is 10 m, what is the maximum volume of material that can be stored?

4.9. **Finding the Volume of a Storage Bin II** Consider the storage bin described in the previous problem.

(a) Calculate the angle θ as shown in the diagram.
(b) For a series of h values between 0 and 10 m, calculate r_h values and bin volumes.
(c) Plot the volume-vs.-height data.

4.10. **Pulley Problem II** A 200-kg mass is attached to a pulley, as shown in Figure 4.P10.

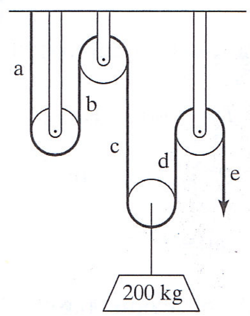

Figure 4.P10
Four-pulley system.

(a) What force must be exerted on cord e to keep the mass from moving?
(b) When the mass is stationary, what is the tension in cords a through e?
(c) Which, if any, of the solid supports connecting the pulleys to the overhead support is in compression?

4.11. **Nonideal Gas Equation** The Soave–Redlich–Kwong (SRK) equation is a commonly used equation of state that relates the absolute temperature T, the absolute pressure P, and the molar volume $\hat{V}$ of a gas under conditions in which the behavior of the gas cannot be considered ideal (e.g., moderate temperature and high pressure). The SRK equation[1] is

$$P = \frac{RT}{(\hat{V} - b)} - \frac{\alpha a}{\hat{V}(\hat{V} + b)} \tag{4.14}$$

where R is the ideal gas constant and α, a, and b are parameters specific to the gas, calculated as follows:

w=.25
111.3=Pc
405.5= Tc

$$\begin{aligned} a &= 0.42747\frac{(RT_C)^2}{P_C}, \\ b &= 0.08664\frac{RT_C}{P_C}, \\ m &= 0.48508 + 1.55171\omega - 0.1561\omega^2, \\ T_r &= \frac{T}{T_C}, \\ \alpha &= \left[1 + m\left(1 - \sqrt{T_r}\right)\right]^2. \end{aligned} \tag{4.15}$$

[1] From *Elementary Principles of Chemical Processes*, 3rd ed., R. M. Felder and R. W. Rousseau, New York: Wiley, 2000.

Here,

T_C is the critical temperature of the gas,

P_C is the critical pressure of the gas, and

ω is the Pitzer acentric factor.

Each of these is readily available for many gasses.
Calculate the pressure exerted by 20 gram-moles of ammonia at 300 K in a 5-liter container, using

(a) the ideal gas equation,
(b) the SRK equation.

The required data for ammonia are tabulated as follows:

$$T_C = 405.5 \text{ K},$$

$$P_C = 111.3 \text{ atm},$$

$$\omega = 0.25.$$

4.12. Projectile Motion III Major-league baseball outfield fences are typically about 350 feet from home plate. Home run balls need to be at least 12 feet off the ground to clear the fence. Calculate the minimum required initial velocity (in miles per hour or km/hr) for a home run, for baseballs hit at the angles 10°, 20°, 30°, and 40° from the horizontal.

PROBLEMS

7.1. Exam Scores Calculate the average and standard deviation for the set of exam scores shown in the accompanying table. Using a 90% = A, 80% = B, and so on, grading scale, what is the average grade on the exam?

Scores
92
81
72
67
93
89
82
98
75
84
66
90
55
90
91

7.2. Thermocouple Reliability I Two thermocouples are supposed to be identical, but they don't seem to be giving the same results when they are both placed in a beaker of water at room temperature. Calculate the mean and standard deviation for each thermocouple. Which one would you use in an experiment?

TC_1 (mv)	TC_2 (mV)
0.3002	0.2345
0.2998	0.1991
0.3001	0.2905
0.2992	0.3006
0.2989	0.1559
0.2996	0.1605
0.2993	0.5106
0.3006	0.3637
0.2980	0.4526
0.3014	0.4458
0.2992	0.3666
0.3001	0.3663
0.2992	0.2648
0.2976	0.2202
0.2998	0.2889