Physics 2425 Practice. Point value is time allotted to answer question. See also Home, 7 habits, periodic table.

Chap. 1 Material

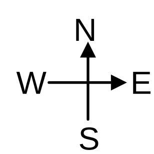
1. 10 Points: Power is given in Watts which, in terms of fundamental units, is $\frac{\text{kg m}^2}{\text{sec}^3}$**.** Show that the unit of $\frac{1}{2}\rho A v^3$ results in units of power where ρ is density with units of kg/m^3, A is area in m^2, and v is velocity in m/sec (10 points).
2. 10 Points: The work (in units of Joules) needed to move a charge through a potential is given by qV where q is the charge in units of Coulombs and V is the voltage in units of volts. q for a single electron is -1.602*10^{-19} Coulomb. An ordinary alkaline battery's voltage is 1.5 V (note – 2 significant figures) and an ordinary battery acts like a pump giving charges greater energy.
   a) How much energy does this battery give a single electron?
   b) What precision, in number of significant figures, is the answer?
3. 5 Points: Convert 60 mi/hr (accurate to 3 sig. figs.) to units of meters per second. 1 km = 0.6214 mi, 1000 m = 1 km, 60 sec = 1 min, 60 min = 1 hr.
4. Give an example of an un-testable hypothesis. Is such a hypothesis "scientific" or "unscientific?" Explain. Is such a hypothesis a scientifically credible alternative to a scientific theory? Explain.

Chap. 2 Material

5. 5 Points: Originally Superman could only leap. When Supergirl came on the scene she could fly, but let's pretend she can only leap too. She leaps with a take-of speed of 64.88 m/sec, the constant acceleration of gravity causes her to come to rest at the top of a building, and it requires 40 sec. Hint: Recall peak speed (take-off speed) is twice the average speed.
   (a) How tall is the building?
   (b) What is the acceleration due to gravity?
   (c) Where do you think this building is located? Hint: Earth's acceleration due to gravity is 9.8 m/sec^2.
6. 10 Points: An outfielder heaves a throw from the outfield to the catcher (a distance of 100 m). Assume the outfielder launches the ball at 45°, that is, the horizontal speed equals the vertical speed. Recall g on Earth is 9.8 m/sec^2.
   (a) How long is the ball in the air?
   (b) What is the horizontal and vertical speed did the outfielder give the ball?
   (c) How high did the ball go?
   (d) What is the vertical speed at the top of the arc?
   (e) What is the horizontal speed at the top of the arc?
7. 10 Points: A stone is thrown upward (straight up) at a speed of 9.3 m/sec. Recall g on Earth is 9.8 m/sec^2.
   (a) How fast is it moving when it reaches 3.9 m?
   (b) How much time does it take to reach this height?
   (c) Why are there two answers to Part b?

Chap. 3 Material

8. 10 Points: Starting at a designated tree, a pirate's treasure is located 54 paces southwest and 29 paces north.
   (a) Draw a sketch. Recall the directions of the compass. ----------------→

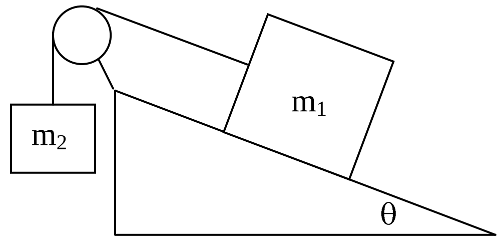


   (b) How many paces (as the crow flies) is the treasure from the starting point (unit of paces, if you like a pace is 2.0 m)?
   (c) What is the angle from due east?
   (d) What is the x coordinate?
   (e) What is the y coordinate?
9. 15 Points: A river is 28 m across, a boat can travel at 6.0 m/sec relative to the water, and the river current is 4.9 m/sec.
   (a) If a boater heads directly toward the opposite shore (perpendicular to the river current), what will be the vector velocity relative to the shore? You may express this in any manner you see fit – length & angle, coordinates, or using unit vectors.
   (b) How long will it take to reach the opposite side?

(c) What is the total distance traveled? In other words, if you put a tape measure from where she started and where she ended up, how long is it?
(d) How far downstream will she travel?

Chap. 4 Material

10. <u>25 Points:</u> A kicker kicks a football with a take-off speed of 27.4 m/sec.
   (a) Show that the take-off angle to achieve the maximum distance is 45°.
   (b) What is that maximum distance kicked?
   (c) What are the components of the take-off velocity vector?
11. <u>25 Points:</u> Refer to the figure at the right.

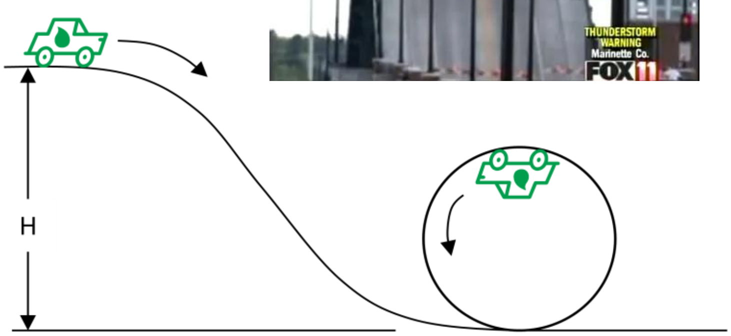


   (a) Derive an expression for the acceleration of the system in terms of m_1, m_2, g and θ.
   (b) What will be the direction of acceleration?
   (c) What does a negative value of the acceleration mean?
   (d) What is the direction of positive acceleration?
   (e) When will the system be in equilibrium (zero acceleration)?
   (f) If m_1 is 71 kg and q is 9.6°, m_2 must be greater than what value to pull m_1 uphill?
   (g) Would the value you calculated for m_2 be different if you did this on the Moon? Explain why or why not?
12. <u>5 Points:</u> What is the net force on an ice cube floating in water?

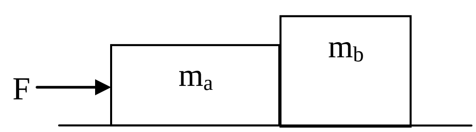
Chap. 5 Material

13. <u>10 Points:</u> Rubber is very sticky stuff. That's why rock climbers wear rubber soled shoes so they can stick to the rock with even a small foothold. On Aug. 14, 2009, a car became stuck on a raised drawbridge in Sturgeon Bay, WI. If the angle of the drawbridge is 45°, what is the minimum coefficient of static friction possible between the tires and the bridge pavement?

14. <u>15 Points:</u> A car starts rolling down a track and goes through a loop. Assuming zero friction, if the loop diameter is d, what height, H, must the car begin at (in terms of d) so that it stays on the track and does not fall off during the loop? Hint: Find what the kinematic equation predicts v^2 is if the car falls straight down. We're using a curved track to change the direction the car moves and later, using conservation of energy, we'll learn that this formula works when we change direction.



15. <u>15 Points:</u> In the figure below, presuming motion with a coefficient of kinetic friction of μ_k, find:
   (a) The acceleration of the system in terms of F, m_a, m_b., μ_k, and g.
   (b) The net force on each block.
   (c) The force of contact that each block exerts on its neighbor.
   (d) If m_a = 21 kg, m_b = 14 kg, F = 92 N, and μ_k = 0.2 give numerical answers to Part (a), (b), and (c).



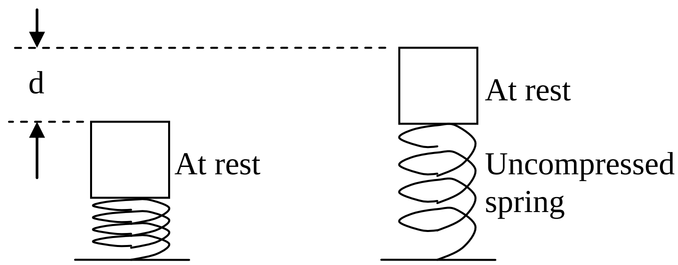
Chap. 6 & 7 Material

16. <u>25 Points:</u> The question to be answered in several parts is: What is the minimum amount of work required to lift a 1000 kg satellite from Earth's surface to geosynchronous orbit?
   (a) Earth is spinning once every 24 hours. What is the KE (kinetic energy) of this satellite on the surface of the earth? R_E = radius of Earth = 6380 km. G = 6.67×10^{-11} N m^2/kg^2.
   m_E = mass of Earth = 5.98×10^{24} kg. g = 9.80 m/sec^2.
   (b) What is the gravitational potential energy at the Earth's surface?

(c) How will you find the altitude for geosynchronous orbit? Write down your starting equation and solve the equation symbolically for R. Hint: this is a *circular* orbit where the period or orbit is exactly one day AND it is strongly recommended you use the formula for centripetal acceleration $a_c = R\,\omega^2$.
(d) What is the numerical value for R for the geosynchronous orbit?
(e) What is the KE of this satellite at geosynchronous orbit? Is it the same as Part A? Why or why not?
(f) What is the GPE (gravitational potential energy) at geosynchronous orbit?
(g) Write a formula to find the work to lift a satellite from Earth to geosynchronous orbit. Recall total energy on the surface of the Earth equals total energy at orbit plus the work. After you write this equation, solve for work.
(h) Numerically evaluate the work required. Note that rockets waste a lot of energy so this is much less than the energy of a rocket. If you could make a perfectly frictionless elevator, this is the energy the elevator would require.

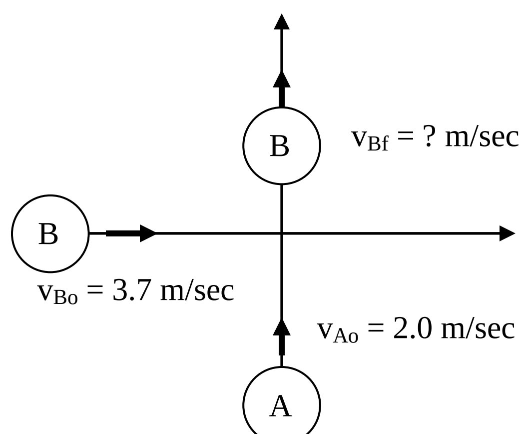
Chap. 8 Material

17. 15 Points: Derive an equation for the velocity of a perfectly circular orbit around the Earth. For R_E = 6380 km, an orbit 200 km above the Earth, G = 6.67×10^{-11} N m^2/kg^2, and $m_E = 5.98 \times 10^{24}$ kg, what is this velocity?
18. 20 Points: When a mass m sits at rest on a spring, the spring is compressed by a distance d from its undeformed length. Suppose instead that the mass is released from rest when it barely touches the undeformed spring. Find the distance D that the spring is compressed before it is able to stop the mass. Does D = d? If not, why not. You won't get a number answer. You need to find an expression for D. Show all work, all steps.



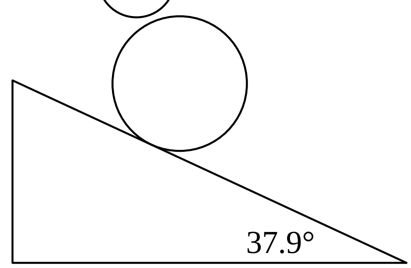
Chap. 9 Material

19. 25 Points: A small ball (m_s = 0.1 kg) moving to the right at 3 m/sec strikes a stationary larger ball (m_l = 0.5 kg) head on. All motion is collinear and the collision is elastic.
(a) What are the velocities of each ball after collision?
(b) Show that energy is conserved.
20. 25 Points: A logger of mass 54 kg is floating downstream on a 1000 kg log at rest relative to the log (long axis pointed along stream) with stream velocity equal 4.9 m/sec. The logger walks along the log at 2 m/sec relative to the log in the same direction as the stream.
(a) What is the velocity of the CM (center of mass) relative to the shore?
(b) What is the logger's speed relative to CM when she is walking? Hint: It is not simply 2 m/sec.
(c) What is the log's speed relative to CM when she is walking?
(d) What is the logger's speed relative to the shore when she is walking? Hint: It is not simply 2 m/sec plus 4.9 m/sec.
(e) What is the log's speed relative to the shore when she is walking?
21. 25 Points: Two billiard balls of equal mass move at right angles and meet at the origin of an xy coordinate system. Initially ball A is moving along the y axis at +2.0 m/sec, and ball B is moving to the right along the x axis with speed +3.7 m/sec. After the elastic collision, the second ball is moving along the positive y axis as shown at right. What is the final direction of ball A and what are the speeds of the two balls? Express answers as formulas then plug in numbers. Explain reasoning clearly.



Chap. 10 & 11 Material

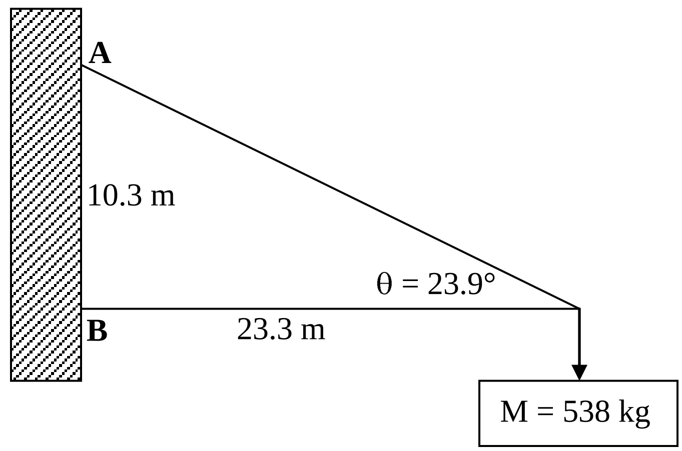
22. 25 Points: A circular hoop of radius 0.513 m and mass 3.34 kg is released from rest and rolls 66.5 m down a hill at angle 37.9°. See diagram at right.



(a) What is the moment of inertia of the hoop about the center of the hoop? I'm not giving you a formula for this since all the mass is at the same radius from the center of the hoop.
(b) What is the moment of inertia of the hoop about the point of contact with the inclined plane? Use parallel axis theorem.
(c) What are the directions and magnitudes of the forces acting on the hoop?
(d) What are the directions and magnitudes of the torques acting on the hoop?
(e) What is the symbolic equation for the force balance?
(f) What is the symbolic equation for the torque balance?
(g) Solve simultaneous equations for acceleration symbolically.
(h) What is the value of acceleration?
(i) What is the formula for the time required?
(j) What is the value for the time required?
(k) How much time would be required if the moment of inertia of the hoop were zero? Pretend it slides without friction down the ramp.

<u>Chap. 12 Material</u>

23. <u>25 Points:</u> A mass hangs from a triangle bracket as shown at right. Calculate the horizontal and vertical components of forces at the points of attachment, A and B. The vertical load is supported equally by points A and B. Express answers as formulas then plug in numbers. Explain reasoning clearly.



24. <u>5 Points:</u> Concrete has a Young's modulus of $20*10^9$ Pa and strength (maximum stress) of $20*10^6$ Pa. If I had a column of concrete 10 m high and 0.5 m^2 area:
(a) What is the maximum weight (in N) I can apply before it fails?
(b) What amount will it compress when the maximum stress is applied?

25. <u>10 Points:</u> Concrete has a Young's modulus of $20*10^9$ Pa and strength (maximum stress) of $20*10^6$ Pa in compression and $2*10^6$ Pa in tension. For a column 2.0 m high and 0.97 m^2 area, answer the following.
(a) What is the maximum weight (in N) in compression that can be applied before it fails?
(b) What amount will it compress when the maximum stress is applied?
(c) What is the maximum weight (in N) in tension that can be applied before it fails?
(d) What amount will it stretches when the maximum stress is applied?

<u>Chap. 13 Material</u>

26. <u>10 Points:</u> A pipe narrows from 10 cm to 5 cm diameter. In the 10 cm pipe water is flowing at 500 kPa (500,000 Pa) pressure at 5 m/sec. There is no change in height. Recall the density of water is 1 gm/cm^3 or, equivalently, 1000 kg/m^3.
(a) What will be the speed in the 5 cm section?
(b) What will be the pressure in the 5 cm section?

27. <u>10 Points:</u> A pipe widens from 2.2 cm to 8.4 cm diameter and drops in height by 4.2 m. In the 2.2 cm pipe water is flowing at 251 kPa pressure at 7.8 m/sec. Recall the density of water is 1 gm/cm^3 or, equivalently, 1000 kg/m^3.
(a) What will be the speed in the 8.4 cm section?
(b) What will be the pressure in the 8.4 cm section?

<u>Chap. 14 Material</u>

28. <u>10 Points:</u> A mass of 1 kg is on a spring with spring constant, k, of 100 N/m.
(a) Write down the formula for the natural frequency and evaluate it.
(b) Write down the formula for the solution.
(c) If displaced at t = 0 sec by 1 cm, what is the function for the solution. Plug in numbers and sketch a graph showing at least one cycle.

<u>Chap. 15 Material</u>

29. 15 Points: A physics and music student wants to create a pipe for an organ that resonates at middle C, f = 262 Hz. The pipe will resonate at it's fundamental frequency (that is lowest frequency – the pipe is half a wavelength long). The speed of sound is 340 m/sec.
  (a) What is the angular frequency ω? Write down the equation, solve the equation symbolically, and then evaluate.
  (b) Write down the appropriate equation for the speed of sound.
  (c) Solve the equation for the speed of sound symbolically to find the wavelength, λ.
  (d) What is the symbolic expression for the wave number k in terms of λ?
  (e) Write down the symbolic expression for the solution of a wave in this pipe. The variable x is zero at the location of the sound generation.
  (f) Evaluate the equations in Parts c and d to find numerical values for k and λ.
  (g) How long is the pipe?
  (h) Write down the numerical solution for a wave in this pipe. Use the variable P_o to express the amplitude.
30. 10 Points: First order interference is observed at a spot 0.8172 m from a central spot when a laser of 632.8 nm illuminates a diffraction pattern 1 m from a projection screen.
  (a) Solve for the angle of the first order interference fringe symbolically in terms of the distance from the screen and the distance of the first order spot from the central spot.
  (b) Solve for the angle of the first order interference fringe in terms of wavelength and diffraction pattern spacing.
  (c) Combine the results of Parts a and b to symbolically find the diffraction pattern spacing.
  (d) Evaluate the result of Part c to numerically calculate the diffraction pattern spacing.
31. 10 Points: First order interference is observed at a spot 0.588 m from a central spot when a laser of 500 nm illuminates a diffraction pattern 1 m from a projection screen.
  (a) Solve for the angle of the first order interference fringe symbolically in terms of the distance from the screen and the distance of the first order spot from the central spot.
  (b) Solve for the angle of the first order interference fringe in terms of wavelength and diffraction pattern spacing.
  (c) Combine the results of Parts a and b to symbolically find the diffraction pattern spacing.
  (d) Evaluate the result of Part c to numerically calculate the spacing of the diffraction pattern

Chap. 16 Material

32. 20 Points: A circus has a pipe organ on a truck and drives it through town at 15 m/sec. You are stationary listening to it on a street corner as the circus drives past. One pipe's fundamental frequency is a fifth above middle C, that is, f = 392 Hz. The speed of sound is 340 m/sec, the density of air is 1.29 kg/m^3, the loudness is 80 db, and recall I_o, the threshold of hearing, is 10^{-12} W/m2.
  (a) What is the angular frequency ω? Write down the equation, solve the equation symbolically, and then evaluate.
  (b) Write down the appropriate equation for the speed of sound given f and λ.
  (c) Solve the equation for the speed of sound symbolically to find the wavelength, λ.
  (d) What is the symbolic expression for the wave number k in terms of λ?
  (e) Write down the symbolic expression for the solution of a wave in this pipe. The variable x is zero at the location of the sound generation.
  (f) Evaluate the equations in Parts c and d to find numerical values for k and λ.
  (g) How long is the pipe?
  (h) What is the intensity of the sound wave?
  (i) What is the maximum change in pressure?
  (j) Write down the numerical solution for a wave in this pipe.
  (k) What is the frequency you will hear if the circus truck is moving toward you?
  (l) What is the frequency you will hear if the circus truck is moving away?

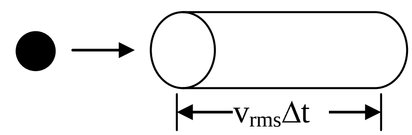
Chap. 17 Material

33. 5 Points:
  (a) What does temperature indicate?
  (b) What is the Celsius temperature of 98.6°F?
  (c) What is the Kelvin temperature of 98.6°F?

34. 10 Points: Some extreme weather regions need to build structures designed for a 100°F temperature difference or more. Parts of West Texas would require this. FYI, Young's modulus for concrete is $20*10^9$ Pa, thermal expansion coefficient is $12*10^{-6}$/°C, maximum stress (in compression) is $20*10^6$ Pa, and $2*10^6$ Pa in tension or shear.
   (a) Under these conditions how much space do you need between concrete slabs 10 m long?
   (b) If you failed to provide this space, what would be the stress?
   (c) Would fracture occur in the absence of spaces?
35. 10 Points:
   (a) What is the volume of 1 mole of gas at STP (0°C and 101,300 Pa). Recall R = 8.314 J/(mole °K), $N_A = 6.02*10^{23}$ molecules/mole, and $k_B = 1.38*10^{-23}$ J/°K.
   (b) What is the volume of 1 mole of gas at 100°C and 202,600 Pa.
   (c) How many molecules are in the gas of Part a? Part b?

Chap. 18 Material

36. 10 Points: One mole of an ideal diatomic nitrogen (m = 28 amu) gas is at 0°C and 101,300 Pa (1 atm). 1 amu = $1.66*10^{-27}$ kg. Calculate:
   (a) Volume.
   (b) Average kinetic energy.
   (c) Total kinetic energy.
   (d) v_{rms}. Hint: This is just the velocity found by setting the answer to Part b to kinetic energy.
37. 15 Points: For the gas in Problem 1 (1 mole diatomic nitrogen, m = 28 amu, 0°C, 101,300 Pa, 1 amu = $1.66*10^{-27}$ kg):
   (a) Derive the expression for mean free path $l_m = \frac{1}{4\pi r^2 (\frac{N}{V})}$. Hint: Think of a tube as shown. The tube radius is twice the molecule radius, r. The molecule travels a distance $v_{rms}\Delta t$ in time Δt. If just one other molecule is in this volume (radius of cylinder is 2r), then the black molecule will hit it.



   (b) The expression in Part a erroneously presumes other molecules are at rest. A more careful (and much more complex) calculation shows that the more accurate expression is: $l_m = \frac{1}{4\sqrt{2}\,\pi r^2 (\frac{N}{V})}$. Using $r = 3*10^{-10}$ m (about the correct size for a nitrogen molecule) and the more accurate expression, calculate the mean free path.

Chap. 19 Material

38. 10 Points: You have an unknown substance that has a grayish appearance and could be Aluminum, iron, or lead. You heat 20 gm of it to the boiling point of water (100°C), and then drop it into a calorimeter containing 20 gm of room temperature (20°C) water (it works because the material is denser than water and the calorimeter is specially designed). Ignore the heat capacity of the calorimeter (assume it's something like Styrofoam). When the system equilibrates the final temperature of both is 22.413°C.
   (a) Set up an equation between all the variables, solve this equation for the specific heat of the substance, and calculate the specific heat.
   (b) What do you think this substance is? Aluminum (specific heat is 0.220 cal/gm °C), Iron (specific heat is 0.110 cal/gm °C), or Lead (specific heat is 0.0311 cal/gm °C)?
   (c) Why is you answer to Part b a reasonable answer?
39. 5 Points: What is the internal energy of 1 mole of ideal monatomic gas at 0°C? 100°C?
40. 5 Points: Using a 1500 W stove burner, how long does it take to boil off (completely convert from liquid to vapor) 1 liter of water starting with liquid at the boiling point and standard pressure? L_v = 2260 kJ/kg.
41. 10 Points: Recall R = 8.314 J/(mole °K) and the heat required to raise the temperature of n moles of gas by ΔT is
   $Q = nC_v\Delta T$ [constant volume]
   $Q = nC_p\Delta T$ [constant pressure]
   Prove (step-by-step algebra, trigonometry, or calculus proof) the following:
      (a) $C_v = 3R/2$ [ideal monatomic gas]

(b) $C_p = C_v + R$ [ideal, not necessarily monatomic, gas]
(c) PV^{γ} = constant [adiabatic process; ideal, not necessarily monatomic, gas]
(d) Calculate the work done in an adiabatic expansion doubling the volume of 1 mole of an ideal gas starting at $V_o = 0.0224\ m^3$, $T_o = 0°C$, and $P_o = 101{,}300$ Pa.

<u>Chap. 20 Material</u>

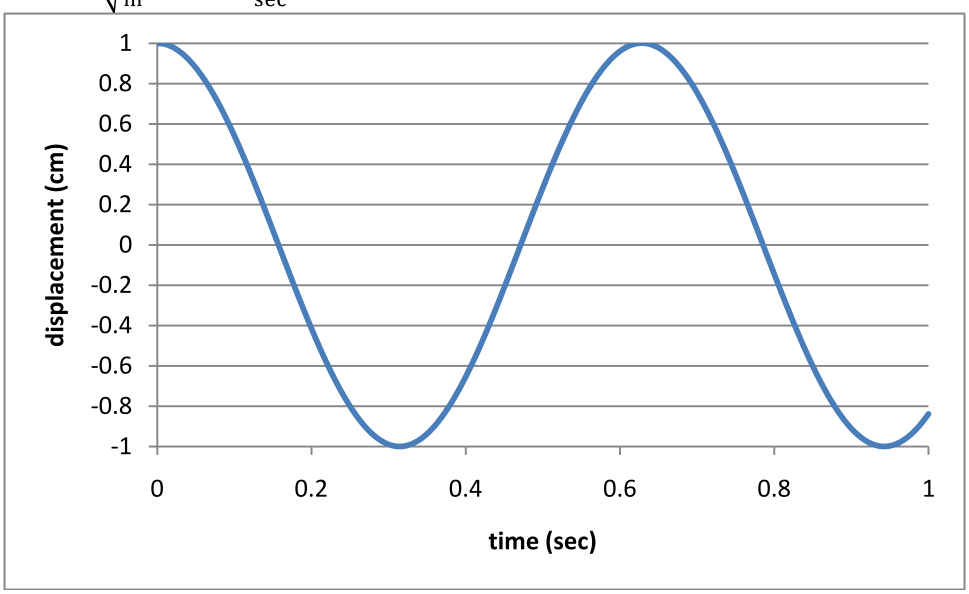
42. <u>10 Points:</u> The working substance of a certain Carnot engine is 1.0 mole of an ideal monatomic gas ($\gamma = 5/3$). During the isothermal expansion portion of this engine's cycle, the volume of the gas doubles, while during the adiabatic expansion the volume increases by a factor of 5.7. The work output of the engine is 920 J in each cycle.
(a) Compute the temperatures of the two reservoirs between which this engine operates.
(b) What is the efficiency of this engine?
43. <u>10 Points:</u> One mole of an ideal monatomic gas expands to double it's volume. Compute the change of the outside entropy, gas entropy, and total entropy under the following three conditions:
(a) Adiabatic expansion.
(b) Isothermal expansion.
(c) Free expansion.
44. <u>10 Points:</u> For a pane of glass (κ = thermal conductivity = $20*10^{-5}$ kcal/m sec °C) 1 m by 1 m pane with temperature on the hot side of 40 °C and temperature on the cold side of 25 °C answer the following:
(a) Compare the heat flow rate (Q/t) of a 6 mm (about ¼") thick pane with a 9 mm (about 3/8") thick pane.
(b) For both cases (6 mm and 9 mm), each second how much entropy does the hot side lose, how much entropy does the cold side gain, and what is the total change in entropy?
(c) Is this consistent with the second law of thermodynamics?

<u>Answers:</u>

1. $\left(\frac{\text{kg}}{\text{m}^3}\right)(\text{m}^2)\left(\frac{\text{m}}{\text{sec}}\right)^3 \ =?\ \frac{\text{kg m}^2}{\text{sec}^3}$
$\left(\frac{\text{kg}}{\cancel{\text{m}^3}}\right)(\text{m}^2)\left(\frac{\cancel{\text{m}^3}}{\text{sec}^3}\right) \ =?\ \frac{\text{kg m}^2}{\text{sec}^3}$
$\frac{\text{kg m}^2}{\text{sec}^3} \ =?\ \frac{\text{kg m}^2}{\text{sec}^3}$ True
2. (a) $2.4*10^{-19}$ J. (b) While the battery voltage is only accurate to 2 sig figs, and thus the answer is only accurate to 2 sig figs, the practice in this class is to ALWAYS keep a minimum of 3 sig figs.
3. $\left(60\frac{\cancel{\text{mi}}}{\cancel{\text{hr}}}\right)\left(\frac{1\ \cancel{\text{km}}}{0.6214\ \cancel{\text{mi}}}\right)\left(\frac{\cancel{\text{min}}}{60\ \text{sec}}\right)\left(\frac{\cancel{\text{hr}}}{60\ \cancel{\text{min}}}\right)\left(\frac{1000\ \text{m}}{\cancel{\text{km}}}\right) = 26.8\ \frac{\text{m}}{\text{sec}}$
4. A magical world closed to ordinary folks exists by passing through Platform 9 ¾ at Kings Cross Station. It is unscientific as it is un-testable. It cannot be seriously considered as an alternative hypothesis.
5. (a) h = 1297.6 m. (b) $a = 1.622\ \frac{\text{m}}{\text{sec}^2}$. (c) The acceleration is not the same as Earth's. It's not on Earth. It's actually on the Moon.
6. (a) t = 4.52 sec. (b) $v_{xo} = v_{yo}$ = 22.1 m/sec. (c) h = 25 m. (d) $v_y = 0$. (e) v_x = 22.1 m/sec.
7. (a) 3.17 m/sec. (b) 0.625 & 1.272 sec. (c) It passes 3.9 one the way up and the way down.
8. (b) 39.3 paces. (c) -166°. (d) -38.18 paces. (e) -9.18 paces.
9. (a) Ordered pair (6 m/sec, 4.9 m/sec). (b) 4.67 sec. (c) 36.2 m. (d) 22.9 m.
10. (a) $\sin(2\theta) = gd/(2v)$ is maximized when θ = 45°. (b) 76.6 m. (c) (19.4 m/sec, 19.4 m/sec).
11. (a) $a = g(m_1\sin\theta - m_2)/(m_1+m_2)$. (b) m_1 moving downhill is positive. (c) negative is when m_1 moves uphill or m_2 moves down. (d) see answer to Part b. (e) $m_1\sin\theta = m_2$. (f) 11.8 kg. (g) no.
12. Zero
13. 1.0
14. H > 5d/4
15. (a) $a = (F - [m_a+m_b]g\mu_k)/(m_a+m_b)$. (b) $F_{net,a} = m_a a$, $F_{net,b} = m_b a$ – this is an acceptable, indeed preferable, answer. It shows you understand that the net force is the mass times acceleration. (c) a = 0.669 m/sec^2, $F_{net,a}$ = 14.04 N, $F_{net,b}$ = 9.36 N.
16. (a) $KE_E = 1.08*10^8$ J. (b) $GPE_E = -6.25*10^{10}$ J. (c) Centripetal force equals gravitational force. Thus $R\omega^2 = GM/R^2$. $R = (GM/\omega^2)^{1/3}$. (d) $4.23*10^7$ m. (e) $KE_o = 4.72*10^9$ J. It is not the same answer as Part a

since the radius increases by a factor of 6.62 (m & ω don't change) and kinetic energy is proportional to this factor squared. (f) GPEo = $-9.44*10^9$ J. (g) W = $E_{T,orbit} - E_{T,surface}$. Inserting expressions for total energy: $W = GMm(1/R_E - 1/R_o) + (0.5)m\omega^2(R_o^2 - R_E^2)$. (h) W = $5.77*10^{10}$ J.

17. $v = \sqrt{\frac{GM}{R}}$. v = 7.79 km/sec.
18. Using conservation of energy equate GPE to SPE. $mgD = (½)kD^2 = (½)(mg/d)D^2$. Solve for D to obtain D = 2d.
19. (a) vl =
20. (a) 4.9 m/sec. (b) 1.90 m/sec. (c) -.10 m/sec. (d) 6.80 m/sec. (e) 4.80 m/sec.
21. v_{Af} = 3.7 m/sec in the x direction and v_{Bf} = 2.0 m/sec (in the y direction).
22. (a) $I = mR^2 = 0.879$ kg m^2. (b) $I_p = 2mR^2 = 1.76$ kg m^2. (c) Gravity acting down, the plane normal, and friction acting up the plane. F_g = 32.7 N (-y direction), F_N = 25.8 N (perpendicular to plane), F_f = ? (acting up the plane). (d) $mgR\sin(\theta) = \tau_{cw} = I_p\alpha$. (e) $mgR\sin(\theta) - F_f = ma$. (f) $mgR\sin(\theta) = 2mR^2(a/R)$. (g) $a = g\sin(\theta)/2$. (h) 3.01 m/sec^2. (i) $t = \sqrt{\frac{4x}{g\sin(\theta)}}$. (j) t = 44.2 sec. (k) t = 31.2 sec.
23. $F_{By} = F_{Ay}$ = 2536.2 N. $F_{By} = -F_{Ay}$ = 11,927 N.
24. (a) $10*10^6$ N. (b) 1 cm.
25. (a) 19,400,000 N. (b) 2 mm. (c) 1,940,000 N. (d) 0.2 mm.
26. (a) 20 m/sec. (b) 312,500 Pa.
27. (a) 0.535 m/sec. (b) 322,437 Pa.
28. (a) $\omega = \sqrt{\frac{k}{m}} = 10\ \frac{\text{radians}}{\text{sec}}$. (b) $x = A\cos(\omega t+\phi)$. (c) x = (1 cm)cos(10t). (d)



29. (a) 1646 rad/sec. (b) $v = \lambda f$. (c) $\lambda = v/f$. (d) $k = 2\pi/\lambda$. (e) $\Delta P = \Delta P_m\cos(kx-\omega t)$. (f) λ = 1.30 m, k = 4.84 m^{-1}. (g) l = 0.649 m. (h) $\Delta P = \Delta P_m\cos(4.84x-1646t)$.
30. (a) $\tan(\theta) = x/y$. $\theta = \tan^{-1}(x/y)$. x = spot distance, y = distance from screen. (b) $\lambda/d = \sin(\theta)$. (c) $d = \lambda/\sin[\tan^{-1}(x/y)]$. (d) d = 1 μm.
31. (a) $\tan(\theta) = x/y$. $\theta = \tan^{-1}(x/y)$. x = spot distance, y = distance from screen. (b) $\lambda/d = \sin(\theta)$. (c) $d = \lambda/\sin[\tan^{-1}(x/y)]$. (d) d = 986 nm.
32. (a) 2463 rad/sec. (b) $v = \lambda f$. (c) $\lambda = v/f$. (d) $k = 2\pi/\lambda$. (e) $\Delta P = \Delta P_m\cos(kx-\omega t)$. (f) λ = 0.867 m, k = 7.24 m^{-1}. (g) l = 0.434 m. (h) $I = I_o10^{(\beta/10)} = 10^{-4}$W/m^2. (i) $\Delta P_m = \sqrt{2v\rho I}$ = 0.296 Pa. (j) ΔP = (0.296 Pa)cos(7.24x-2463t). (k) $f' = fv_s/(v_s-v)$ = 410 Hz. (l) $f' = fv_s/(v_s+v)$ = 375 Hz.
33. (a) Average internal energy. (b) T_c = 37°C. (c) 310.15°K.

34. (a) $\Delta l = l_o\alpha\Delta T$ = 6.67 mm. (b) stress = $\sigma = E\alpha\Delta T$ = 13.3 MPa. (c) Although less than the maximum stress in compression, it exceeds the maximum stress in tension. Any defect would cause tensile stress and failure.
35. (a) 22.4 liter. (b) 15.3 liter. (c) This is a trick question (AKA conceptual question). One mole always has $6.02*10^{23}$ molecules.
36. (a) 22.4 liter. (b) $KE_{ave} = 2.5kT = 9.42*10^{-21}$ J. (c) 5673 J. Note: this is total internal energy – the gas does not have uniform motion. (d) 637 m/sec.
37. (a) When the volume of one molecule equals the volume of the cylinder that provides l_m = mean free path = $v_{rms}\Delta t$. $V/N = V_{cyl} = 4\pi r^2 l_m$. $l_m = \frac{1}{4\pi r^2 (\frac{N}{V})}$. (b) $2.33*10^{-8}$ m.
38. (a) c = 0.0311 cal/gm °C. (b) Lead. (c) Water temperature only rises slightly, thus the metal has low specific heat. My first guess would be lead.
39. (a) 3404 J. (b) 4650 J.
40. 1507 sec = 25.1 min.
41. Pp. 511-515 of textbook provides very good proofs. (d) -3403 J. The gas is losing energy by doing work.
42. T_l = 73°K & T_h = 233°K
43. (a) Zero. No heat flow, no entropy change. (b) ΔE_{int} = zero. dQ = PdV.
$\Delta S = \Delta Q/T = nR\ln(2)$ = entropy gained = -entropy change of environment. This is reversible process and, thus, total entropy change is zero. (c) Free expansion is irreversible and no heat comes in from outside environment (ΔS of environment = 0). But entropy is a state variable and, thus, the gas changes by the same at Part b. $\Delta S = nR\ln(2)$ = total entropy change.
44.

	6 mm	9 mm
(a) $\Delta Q/\Delta T$	0.5 kcal/sec	0.333 kcal/sec
(b) ΔS_h	-1.60 cal/°K	-1.06 cal/°K
ΔS_c	1.68 cal/°K	1.12 cal/°K
ΔS_{total}	0.0804 cal/°K	0.0536 cal/°K