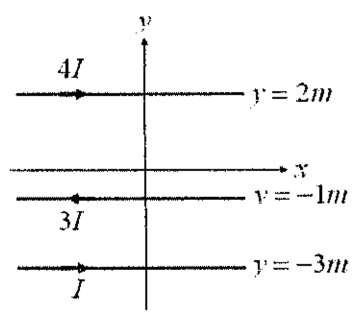
7. If n moles of an ideal gas are compressed isothermally from an initial volume V_1 to a final volume $\mathbf{V_2}$, the change in entropy is

a. $nR \ln (V_2 / V_1)$
b. $nRT \ln (V_2/ V_1)$
c. $nk_B \ln (V_2/ V_1)$
d. $n\, C_v \int dT/T$
e. $n\, C_v/T$

8. A long straight metal rod has a radius of ***2.0 mm*** and a surface charge of density ***0.40 nC/m²***. Determine the magnitude of the electric field ***3.0 mm*** from the axis.

a. 18 N/C
b. 23 N/C
c. 30 N/C
d. 15 N/C
e. 60 N/C

9. Three long wires parallel to the x axis carry currents as shown. If $I = 20\ A$, what is the magnitude of the magnetic field at the origin?



$$\frac{\mu_0}{4\pi} = 10^{-7}\,Tm/A$$

a. 37 μT
b. 28 μT
c. 19 μT
d. 47 μT
e. 58 μT

10. Monochromatic light (**λ = 500 nm**) is incident on a soap bubble (**n = 1.40**). How thick is the bubble (***in nm***) if destructive interference occurs in the reflected light?

a. 102
b. 179
c. 54
d. 1
e. 89

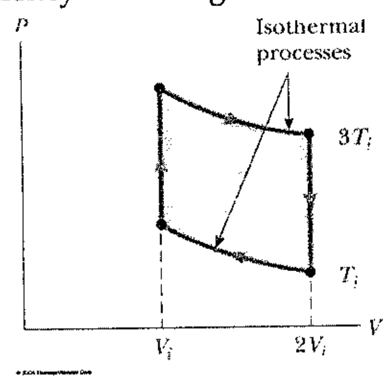
Question (20 points)

1. Is it possible for two objects to be in thermal equilibrium if they are not in contact with each other? Explain.
2. If the wavelength of sound is reduced by a factor of 2, what happens to its frequency? Its speed?
3. What is the advantage of transmitting power at high voltages?
4. Holding your hand at arm's length, you can readily block sunlight from reaching your eyes. Why can you not block sound from reaching your ears this way?

Problems (30 points)

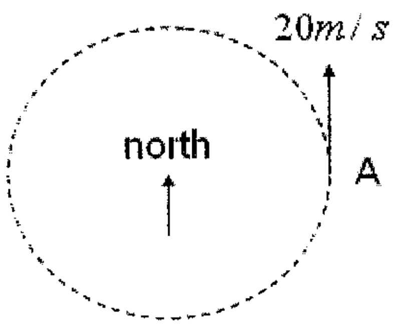
1. A conducting spherical shell of radius *15.0 cm* carries a net charge of $-6.40\ \mu C$ uniformly distributed on its surface. Find the electric field at points (a) just outside the shell and (b) inside the shell.

2. Consider n mol of an ideal monatomic gas being taken once through the cycle, consisting of two isothermal processes at temperatures $3T_i$ and T_i and two constant-volume processes. Determine, in terms of n, R, and T_i, (a) the net energy transferred by heat to the gas and (b) the efficiency of the engine.



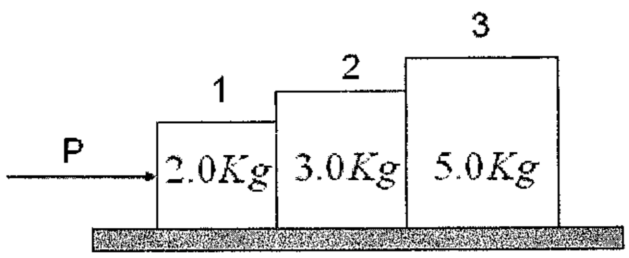
Multiple Choice (50 points)

1. A car travels counterclockwise around a flat circle of radius *0.25 km* at a constant speed of *20 m/s*. When the car is at point A as shown in the figure, what is the car's acceleration?



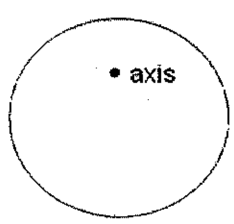
a. 1.6 m/s^2, east
b. Zero
c. 1.6 m/s^2, east
d. 1.6 m/s^2, north
e. 1.6 m/s^2, west

2. If ***P* = 6.0 *N***, what is the magnitude of the force exerted on block *1* by block 2 ?



a. 6.4 N
b. 5.6 N
c. 4.8 N
d. 7.2 N
e. 8.4 N

3. In the figure below, a disk (radius ***R* = 1.0 *m*, *mass* = 2.0 *kg***) is suspended from a pivot a distance ***d* = 0.25 *m*** above its center of mass. The angular frequency (in ***rad/s***) for small oscillations is approximately

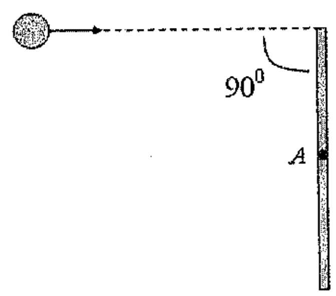


a. 4.2
b. 2.1
c. 1.5
d. 1.0
e. 3.8

4. A uniform rod (*mass* = *1.5 kg*) is *2.0 m* long. The rod is pivoted about a horizontal, frictionless pin through one end. The rod is released from rest in a horizontal position. What is the angular speed of the rod when the rod makes an angle of $30°$ with the horizontal? (The moment of inertia of the rod about the pin is $2.0\ kg \cdot m^2$).

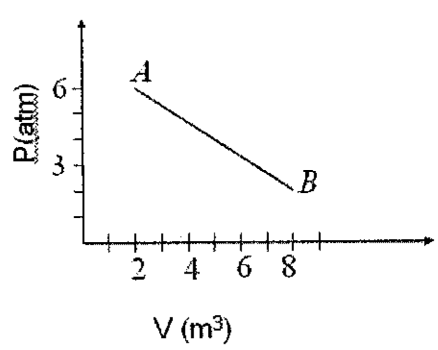
   a. 2.2 rad/s
   b. 3.6 rad/s
   c. 2.7 rad/s
   d. 3.1 rad/s
   e. 1.8 rad/s

5. A thin rod of mass M and length L is struck at one end by a ball of clay of mass m, moving with speed v as shown in the figure. The ball sticks to the rod. After the collision, the angular momentum of the clay-rod system about **A**, the midpoint of the rod, is



   a. $(m + M/3)(vL/2)$
   b. $(m + M/12)(vL/2)$
   c. $(m + M/6)(vL/2)$
   d. $mvL/2$
   e. mvL

6. A gas expands as shown in the graph. If the heat taken in during this process is $1.02 \times 10^6\ J$ and $1\ atm = 1.01 \times 10^5\ N/m^2$, the change in internal energy of the gas (in J) is



   a. -2.42×10^6
   b. -1.40×10^6
   c. -1.02×10^6
   d. 1.02×10^6
   e. 1.40×10^6