Multiple Choice (50 points)

1. A 2.0-kg object moving 5.0 m/s collides with and sticks to an 8.0-kg object initially at rest. Determine the kinetic energy lost by the system as a result of this collision.

   a. 20 J
   b. 15 J
   c. 30 J
   d. 25 J
   e. 5.0 J

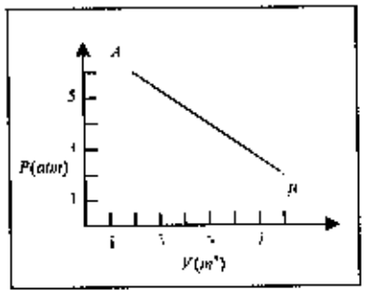
2. A uniform rod (mass = 2.0 kg, length = 0.60 m) is free to rotate about a frictionless pivot at one end. The rod is released from rest in the horizontal position. What is the magnitude of the angular acceleration of the rod at the instant it is 60° below the horizontal?

   a. 15 rad/s^2
   b. 12 rad/s^2
   c. 18 rad/s^2
   d. 29 rad/s^2
   e. 23 rad/s^2

3. A massless rope is wrapped around a uniform cylinder that has radius R and mass M, as shown in the figure. Initially, the unwrapped portion of the rope is vertical and the cylinder is horizontal. The linear acceleration of the cylinder is

   a. $(2/3)g$
   b. $(1/2)g$
   c. $(1/3)g$
   d. $(1/6)g$
   e. $(5/6)g$

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



a. -2.42×10^5
b. -1.40×10^5
c. -1.02×10^5
d. 1.02×10^5
e. 1.40×10^5

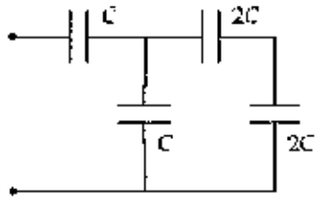
5. If n moles of an ideal gas are compressed isothermally from an initial volume V_1 to a final volume V_2, the change in entropy is

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. $n\,C_v/T$

6. A series of n uncharged concentric shells surround a small central charge q. The charge distributed on the outside of the nth shell is

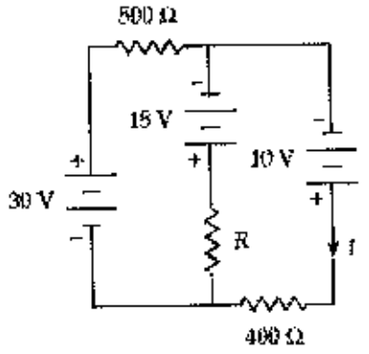
a. $-nq$.
b. $-(1/n)q$.
c. $+q$.
d. $+(1/n)q$.
e. $+nq$.

7. Determine the equivalent capacitance of the combination shown when C = 45 μF.



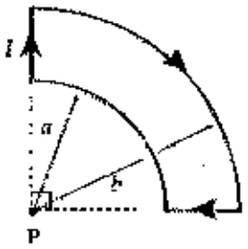
a. 36 μF
b. 32 μF
c. 34 μF
d. 30 μF
e. 38 μF

8. Determine the magnitude and sense (direction) of the current in the 500-Ω resistor when $I = 30$ mA.



a. 56 mA left to right
b. 56 mA right to left
c. 48 mA left to right
d. 48 mA right to left
e. 26 mA left to right

9. What is the magnitude of the magnetic field at point P if $a = R$ and $b = 2R$?



a. $\frac{\mu_0 I}{6R}$
b. $\frac{3\mu_0 I}{16R}$
c. $\frac{\mu_0 I}{12R}$
d. $\frac{\mu_0 I}{16R}$
e. $\frac{\mu_0 I}{32R}$

10. A film of index of refraction n_1 coats a surface with index of refraction n_2. When $n_1 > n_2$, the condition for constructive interference for reflected monochromatic light of wavelength λ in air is

a. $t = m\frac{\lambda}{n_1}$.
b. $t = \left(m + \frac{1}{2}\right)\frac{\lambda}{n_1}$.
c. $2t = m\frac{\lambda}{n_1}$.
d. $2t = \left(m + \frac{1}{2}\right)\frac{\lambda}{n_1}$.
e. $4t = m\frac{\lambda}{n_1}$.

Questions and Problems (50 %)

1. (15%) (a) Determine the acceleration of the center of mass of a uniform solid disk rolling down an incline making angle θ with the horizontal. Compare this acceleration with that of a uniform hoop. (b) What is the minimum coefficient of friction required to maintain pure rolling motion for the disk?

2. (10%) A 5.00-g bullet moving with an initial speed of 400 m/s is fired into and passes through a 1.00-kg block, as in Fig. 1. The block, initially at rest on a frictionless, horizontal surface, is connected to a spring of force constant 900 N/m. If the block moves 5.00 cm to the right after impact, find (a) the speed at which the bullet emerges from the block and (b) the mechanical energy converted into internal energy in the collision.

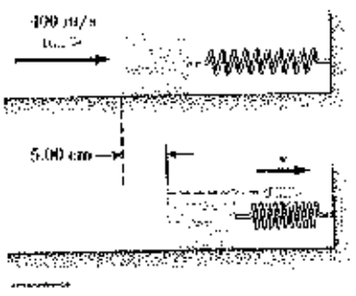


Fig. 1

3. (a) In the absence of any dielectric or magnetic materials, please describe in detail the four Maxwell's equations in integral form. (4%)
   (b) In Faraday's law, is the induced electric field conservative or non-conservative? Please illustrate it briefly. (5%)
   (c) In a RC circuit, please prove that the magnitude of the conduction current in the conducting wire is equal to the magnitude of the displacement current across the capacitor. (6%)

4. Yellow sodium light, which consists of two wavelengths, $\lambda_1 = 589.00$ nm and $\lambda_2 = 589.59$ nm, falls on a 7500-line/cm diffraction grating. Determine
   (a) the maximum order that will be present for sodium light, (5%)
   (b) the width of grating necessary to resolve the two sodium lines. (5%)