UNIVERSITY OF GAZIANTEP
DEPARTMENT OF ENGINEERING PHYSICS

EP 105 General Physics I
Final Exam Questions **FALL SEMESTER**
Date: 17/01/2008 Time: 100 min.

Student No	Name	Surname	Dep.	Signature

Ques.	Mark
1	
2	
3	
4	
5	
6	
Total	
OUT OF	100

*** * * SOLVE ONLY 5 OUT OF 6 QUESTIONS * * ***

- The steps of solution of each problem should be shown clearly in the space given.
- Write your answers in boxes provided, otherwise your answer will not be considered.
- Constants: $g = 9.8\ \text{m/s}^2$

QUESTION 1 (20 %)

An object is suspended by a cord as shown in Fig I and the tension in the cord is $T_1 = 10$ N. The object is then immersed to the water as shown in Fig II. In this case the tension in the cord is $T_2 = 6$ N. Determine the mass density of the object.
(Density of the water is given as: $\rho_w = 1000\ \text{kg/m}^3$)

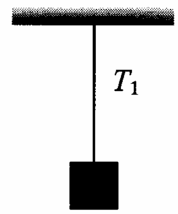


Fig I

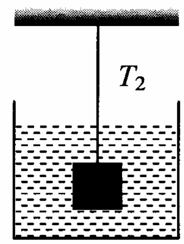
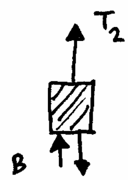


Fig II

Equilibrium conditions for each case:

$$T_1 = mg \quad (1)$$



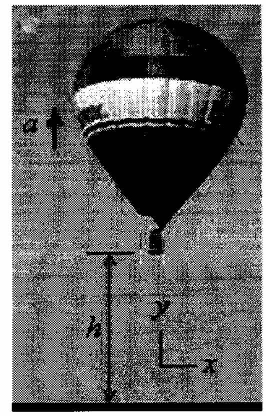
$$B = mg - T_2$$
$$\rho_w V g = T_1 - T_2 \quad (2)$$

Density of the object:

$$\rho = \frac{m}{V} = \frac{mg}{Vg} = \frac{T_1}{(T_1 - T_2)/\rho_w} = \left(\frac{T_1}{T_1 - T_2}\right)\rho_w$$
$$= \left(\frac{10}{10-6}\right)(1000)$$
$$= 2500\ \text{kg/m}^3$$

$$\boxed{\rho = 2500\ \text{kg/m}^3}$$

QUESTION 2 (20 %)



A hot-air balloon which is initially at rest is rising vertically at a constant acceleration of $a = 2$ m/s^2. When the balloon is $h = 225$ m above the ground, an object of negligible mass is dropped (released) from the balloon at time $t = 0$.

(a) Find the velocity of the balloon at height $h = 225$ m

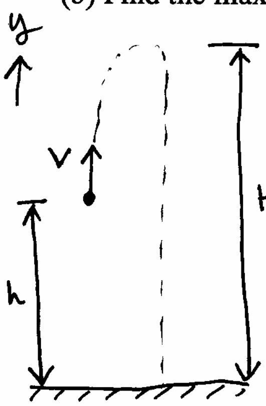
$$v^2 = \cancel{v_0^2}^{\to 0} + 2ah \rightarrow v = \sqrt{2ah}$$

$$= \sqrt{(2)(2)(225)}$$

$$= 30 \text{ m/s}$$

$$\boxed{v = 30 \text{ m/s}}$$

(b) Find the maximum height H from the ground reached by the object



$$v'^2 = v^2 - 2g(H-h)$$

$$0 = v^2 - 2g(H-h)$$

or

$$H = \frac{v^2}{2g} + h = \frac{30^2}{2 \times 9.8} + 225 = 270.9 \text{ m}$$

$$\boxed{H = 270.9 \text{ m}}$$

(c) Find the time t at which the object hits the ground

$$y = y_0 + vt - \frac{1}{2}gt^2$$

$$0 = h + vt - \frac{1}{2}gt^2$$

or

$$4.9t^2 - 30t - 225 = 0$$

$$t_{12} = \frac{30 \mp \sqrt{30^2 - 4(4.9)(-225)}}{(2)(4.9)}$$

$$\therefore \boxed{t_1 = 10.5 \text{ s}} \checkmark$$

$$t_2 = -4.4 \text{ s} \quad \times$$

$$\boxed{t = 10.5 \text{ s}}$$

(d) Find the height from the ground of the balloon when the object hits the ground

$$h' = h + vt + \frac{1}{2}at^2$$

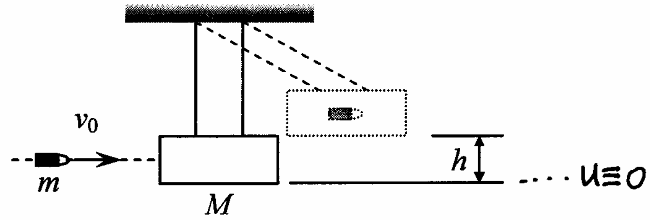
$$= 225 + 30(10.5) + \frac{1}{2}(2)(10.5)^2$$

$$= 650.25 \text{ m}$$

$$\boxed{h' = 650.25 \text{ m}}$$

QUESTION 3 (20 %)

The ballistic pendulum (as in the figure) is a system used to measure the speed of a bullet. A bullet of mass m = 5 g is fired into a large wooden block of M = 1 kg suspended from light wires. The bullet embeds in the block, and the entire system swings through a height h = 5 cm.



(a) Find the initial speed (v_0) of the bullet

Conservation of momentum:

$$m v_0 = (m+M)\, v \qquad (1)$$

where v is the common velocity of the system $m+M$ after the collision.

mechanical energy is conserved after the collision.

$$K_i + \cancel{U_i}^{\,0} = \cancel{K_f}^{\,0} + U_f$$

$$\frac{1}{2} \cancel{(m+M)}\, v^2 = \cancel{(m+M)}\, g h$$

$$v^2 = 2 g h \qquad (2)$$

Combining Eqn (1) and (2) and solving for v_0

$$v_0 = \left(\frac{m+M}{m}\right) \sqrt{2 g h}$$

$$= \left(\frac{5 \times 10^{-3} + 1}{5 \times 10^{-3}}\right) \sqrt{(2)(9.8)(5 \times 10^{-2})}$$

$$= 199 \text{ m/s}$$

$$\boxed{v_0 = 199 \text{ m/s}}$$

(b) Find the loss in mechanical energy (ΔE) due to the collision

Mechanical energy before collision:

$$E_1 = \frac{1}{2} m v_0^2 = \frac{1}{2}(5 \times 10^{-3})(199)^2 = 99 \text{ J}$$

mechanical energy after collision:

$$E_2 = \frac{1}{2}(m+M) v^2 = (m+M) g h$$

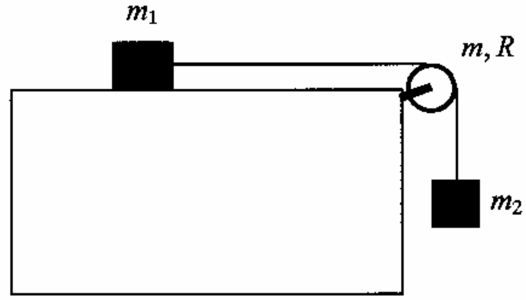
$$= (5 \times 10^{-3} + 1)(9.8)(5 \times 10^{-2})$$

$$= 0.49 \text{ J}$$

$$\therefore \Delta E = E_2 - E_1 = -98.5 \text{ J}$$

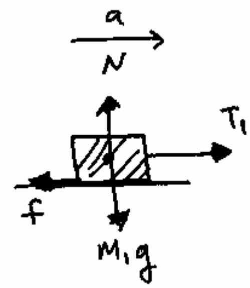
$$\boxed{\Delta E = -98.5 \text{ J}}$$

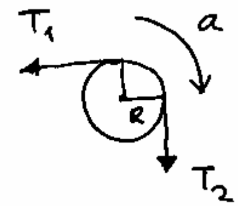
QUESTION 4 (20 %)



Two blocks, m_1= 2 kg and m_2 = 5 kg, are connected by a light strings that passes over a pulley of radius R = 10 cm and mass m = 1 kg as seen in the figure. The coefficient of kinetic friction between the mass m_1 and surface is μ = 0.2. (Moment of inertia of the pulley about its center of mass is $I = mR^2/2$)

(a) Calculate the common acceleration of the blocks





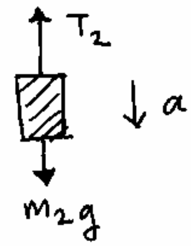
Newton's 2nd Law

for block 1 : $T_1 - f = m_1 a$

$$T_1 - \mu m_1 g = m_1 a \quad (1)$$

$f = \mu N = \mu m_1 g$

for block 2 : $m_2 g - T_2 = m_2 a \quad (2)$



for pulley : $\tau = I \alpha$

$$(T_2 - T_1) R = \left(\frac{mR^2}{2}\right) \frac{a}{R}$$

$$T_2 - T_1 = \frac{ma}{2} \quad (3)$$

Adding Eqn (1), (2) and (3) gives:

$$a = \left(\frac{m_2 - \mu m_1}{m_2 + m_1 + m/2}\right) g = \left(\frac{5 - 0.2 \times 2}{5 + 2 + 1/2}\right) 9.8 = 6 \ m/s^2$$

$$\boxed{a = 6 \ m/s^2}$$

(b) Calculate tensions in the string

Using Eqn (1) : $T_1 = m_1 (a + \mu g) = 2(6 + 0.2 \times 9.8) \approx 16 \ N$

Using Eqn (2) : $T_2 = m_2 (g - a) = 5(9.8 - 6) = 19 \ N$

$$\boxed{T_1 = 16 \ N}$$

$$\boxed{T_2 = 19 \ N}$$

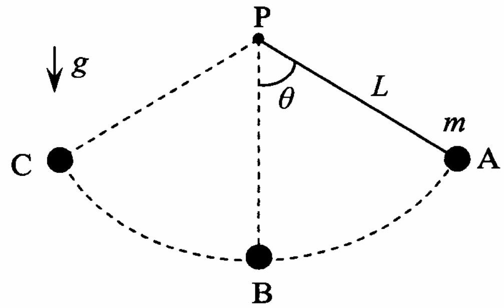
(c) Calculate angular acceleration of the pulley

$$\alpha = \frac{a}{R} = \frac{6}{0.1} = 60 \ rad/s^2$$

$$\boxed{\alpha = 60 \ rad/s^2}$$

QUESTION 5 (20 %)

A pendulum consists of a ball of mass m = 2 kg attached to a light cord of length L = 3.2 m as shown in Figure. The ball is released from rest at point A when the cord makes an angle θ = 60° with the vertical. The ball passes through its lowest point B and stops at point C. Ignore all possible frictions in the system.

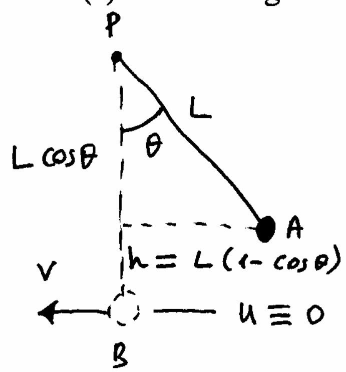


(a) Find the rotational inertia of the ball about point P

$$I = mL^2 = 2 \times (3.2)^2 = 20.5 \text{ kg}\cdot\text{m}^2$$

$$\boxed{I = 20.5 \text{ kg}\cdot\text{m}^2}$$

(b) Find the angular speed of the ball (about point P) at point B



Conservation of Energy:

$$\cancel{K_A}^{0} + u_A = K_B + \cancel{u_B}^{0}$$

$$\cancel{m}gh = \frac{1}{2}\cancel{m}v^2$$

$$v = \sqrt{2gh}$$

$$= \sqrt{2gL(1-\cos\theta)}$$

$$= \sqrt{(2)(9.8)(3.2)(1-\cos 60)}$$

$$= 5.6 \text{ m/s}$$

Angular velocity:

$$\omega = \frac{v}{L}$$

$$= \frac{5.6}{3.2}$$

$$= 1.75 \text{ rad/s}$$

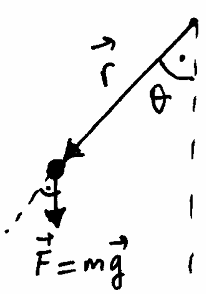
$$\boxed{\omega = 1.75 \text{ rad/s}}$$

(c) Find the magnitude of the angular momentum (about point P) of the ball at point B

$$\ell = I\omega = (20.5)(1.75) = 35.9 \text{ kg}\cdot\text{m}^2/\text{s}$$

$$\boxed{\ell = 35.9 \text{ kg}\cdot\text{m}^2/\text{s}}$$

(d) Find the magnitude of the torque exerted (about point P) on the ball at point C



$$|\vec{\tau}| = |\vec{r} \times \vec{F}| = rF\sin\theta$$

$$= Lmg\sin\theta$$

$$= (3.2)(2)(9.8)\sin 60°$$

$$= 54.3 \text{ N}\cdot\text{m}$$

$$\boxed{\tau = 54.3 \text{ N}\cdot\text{m}}$$

QUESTION 6 (20 %)
A block of mass m = 680 g is fastened to a spring whose spring constant is k = 65 N/m. The block is pulled a distance x = 11 cm from its equilibrium position and then released from rest.

(a) What force does the spring exert on the block just before it is released?

$$F = |-kx| = |-(65)(0.11)| = 7.15 \text{ N}$$

$$\boxed{F = 7.15 \text{ N}}$$

(b) What is the amplitude of the oscillation?

Since maximum distance is given as $x = 11$ cm

$$A = x = 11 \text{ cm} = 0.11 \text{ m}$$

$$\boxed{A = 0.11 \text{ m}}$$

(c) What is the period of the oscillation?

$$\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{65}{0.68}} = 9.78 \text{ rad/s}$$

$$T = \frac{2\pi}{\omega} = \frac{2\pi}{9.78} = 0.64 \text{ s}$$

$$\boxed{T = 0.64 \text{ s}}$$

(d) What is maximum speed of the oscillating block?

$$v_{max} = \omega A = (9.78)(0.11) = 1.08 \text{ m/s}$$

$$\boxed{V_{max} = 1.08 \text{ m/s}}$$