Kuwait University
Physics Department

Physics 101

Final Exam

Autumn Semester
Thursday, January 15, 2004
11:00 a.m. – 1:00 p.m.

Student's Name: .... الحل النموذجي ....

Student's Number: ....

Choose your Instructor's Name :

Prof. Fekri El-Akkad.
Dr. Ahmed Ali Al-Jassar
Dr. Ismail Sabbah
Dr. Abdel Muhsen Habib
Dr. Hala Khalid Al-Jassar
Dr. Afifa Bahbehani
Dr. Adnan Al-Yaseen
Dr. Yaccob Makdisi
Dr. Majed Ali Fehmi

Grads:

Problem	1	2	3	4	5	6	7	8	9	10	11	12	Total
Points													

Important Notes:

1. Answer all questions.
2. Each question will be assigned 2 points.
3. The solution should be given explicitly for each problem.
4. No solution = no points.
5. Check the correct answer for each question.
6. Take $g = 10\ m/s^2$
7. Mobiles and Pagers are not allowed during the exam.
8. Programmable calculators which can store equations are not allowed.
9. Some Rotational Inertias

OBJECT (mass M)	AXIS	MOMENT OF INERTIA (I)
Thin rod of length L	Through center ⊥ rod	$1/12\ ML^2$
Solid sphere of radius R	Through center	$2/5\ MR^2$
Solid disk or cylinder of radius R	Through center	$1/2\ MR^2$

1. A motion of a particle is defined by, $x(t) = 5 + 3t + t^2 + 2t^3$ where x is in meters and t is in seconds. The average acceleration of the particle (in m/s^2) between t = 0 and t = 1 (s) is:

a) 13 b) 12 c) 11 d) 10 e) 8 f) Other

$$v = \frac{dx}{dt} = 3 + 2t + 6t^2$$

$$v(0) = 3 \text{ m/s}, \quad v(1) = 3 + 2 + 6 = 11 \text{ m/s}$$

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{v(1) - v(0)}{1 - 0} = \frac{11 - 3}{1 - 0} = \boxed{8 \text{ m/s}^2}$$

2. The work (in Joules) that is done by a constant force **F** = (4i + 3j) N to move a particle of mass 2 kg from point (1, -3, 4) m to a point (2, 2, 5) m is:

a) 30 b) 26 c) 19 d) 20 e) 3 f) Other

$$\Delta\vec{r} = (2\hat{i} - \hat{i}) + (2\hat{j} + 3\hat{j}) + (5\hat{k} - 4\hat{k}) = \hat{i} + 5\hat{j} + \hat{k}$$

$$W = \vec{F} \cdot \Delta\vec{r} = (4\hat{i} + 3\hat{j}) \cdot (\hat{i} + 5\hat{j} + \hat{k})$$

$$= 4 + 15 = \boxed{19 \text{ Joules}}$$

3. The magnitude of torque (in N.m) about the origin on an object of mass 2 kg located at point (4, 2, 3) m due to force F = (3i) N is approximately:

a) 11 b) 14 c) 18 d) 22 e) 24 f) Other

$$\vec{\tau} = \vec{r} \times \vec{F}$$

$$= (4\hat{i} + 2\hat{j} + 3\hat{k}) \times (3\hat{i})$$

$$= -6\hat{k} + 9\hat{j}$$

$$\tau = \sqrt{36 + 81} = 10.8 \simeq \boxed{11 \text{ N.m}}$$

4. A stone is dropped from the roof of a high building. A second stone is dropped 1.5 s later. How far apart (in m) are the stones when the second stone has reached a speed of 12 m/s?

a) 6.8 b) 18 (c) 29.3) d) 10.5 e) 12 f) Other

$$\Delta y = v_{0y} t - \frac{1}{2} g t^2$$

$$= (-12)(1.5) - \frac{1}{2}(10)(1.5)^2 = -29.3 \text{ m}$$

The the distance between the two stones $= \boxed{29.3 \text{ m}}$

5. A particle starts from the origin at t = 0 with a velocity of (6i) m/s and moves in the x y plane with a constant acceleration of (-2i + 4j) m/s^2. At the instant the particle achieves its maximum positive x coordinate, how far (in m), approximately, is it from the origin?

a) 30 (b) 20) c) 45 d) 27 e) 37 f) Other

$$v_x = v_{0x} + a_x t \Rightarrow 0 = 6 + (-2)t \Rightarrow t = 3 \text{ (s)}$$

$$\Delta \vec{r} = \vec{v}_0 t + \frac{1}{2} \vec{a} t^2 \Rightarrow \Delta \vec{r} = \vec{r} - \vec{r}_0$$

$$= 6\hat{i}(3) + \frac{1}{2}(-2\hat{i} + 4\hat{j})9$$

$$= 18\hat{i} - 9\hat{i} + 18\hat{j}$$

$$\vec{r} - 0 = 9\hat{i} + 18\hat{j} \Rightarrow |\vec{r}| = \sqrt{9^2 + 18^2}$$

$$= 20.12$$

$$\simeq \boxed{20 \text{ m}}$$

6. At the instant 2 kg particle has a velocity of 4 m/s in the positive x direction, a 3 kg particle has a velocity of 5 m/s in the positive y direction. What is the speed (in m/s) of the center of mass of the two-particle system?

a) 3.8 (b) 3.4) c) 5.0 d) 4.4 e) 4.6 f) Other

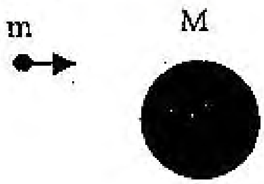
$$\vec{v}_{cm} = \frac{m \vec{v}_1 + m_2 \vec{v}_2}{m_1 + m_2} = \frac{2(4\hat{i}) + 3(5\hat{j})}{5}$$

$$= (1.6\hat{i} + 3\hat{j}) \text{ m/s}$$

$$v_{cm} = \sqrt{11.56} = \boxed{3.4 \text{ m/s}}$$

7. A particle of mass m = 100 g and speed v = 5 m/s collides and sticks to the end of a uniform disk of mass M = 1 kg and radius R = 20 cm. If the disk is initially at rest and is pivoted about a frictionless axle through its center, then the final angular velocity (in rad/s) after the collision is approximately:

a) 8 b) 2 c) 6 (d) 4) e) 10 f) Other



$$L_i = L_f$$

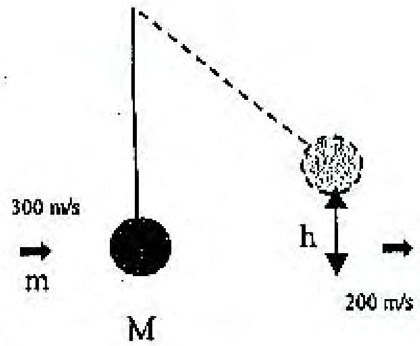
$$m v R = \left(m R^2 + \tfrac{1}{2} M R^2\right) \omega$$

$$(0.1)(5)(0.2) = (0.1 + 0.5)(0.2)^2 \, \omega$$

$$\omega = \frac{0.5}{(0.6)(0.2)} = 4.2 \simeq \boxed{4 \text{ rad/s}}$$

8. A bullet of mass m = 0.02 kg and speed of 300 m/s passes completely through a pendulum ball of mass M = 0.5 kg. If the bullet emerges with speed of 200 m/s, then the ball will rise a height (in m) of:

a) 8 b) 2 (c) 0.8) d) 0.2 e) 0.1 f) Other



$$P_i = P_f$$

$$m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f}$$

$$(0.02)(300) + (0.5)(0) = (0.2)(200) + (0.5)(v_{2f})$$

$$v_{2f} = \frac{6-4}{0.5} \Rightarrow 4 \text{ m/s}$$

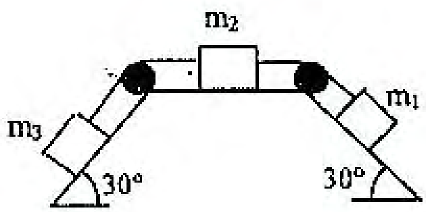
$$E_i = E_f$$

$$mgh = \tfrac{1}{2} m v^2$$

$$h = \frac{v^2}{2g} = \frac{16}{20} = \boxed{0.8 \text{ m}}$$

9. If m_1 = 10 kg, m_2 = 6 kg, m_3 = 4 kg and the pulleys are massless and the surfaces are frictionless, then the acceleration (in m/s^2) of m_1 is:

a) 2.5 b) 2 (c) 1.5) d) 1.0 e) 3.0 f) Other



$$m_1 g \sin\theta - T_1 = m_1 a$$

$$T_1 - T_2 = m_2 a \quad +$$

$$T_2 - m_3 g \sin\theta = m_3 a$$

$$m_1 g \sin\theta - m_3 g \sin\theta = (m_1 + m_2 + m_3) a$$

$$(10)(10)(0.5) - (4)(10)(0.5) = (10 + 6 + 4) a$$

$$\rightarrow a = \boxed{1.5 \text{ m/s}^2}$$

10. A skier of mass m = 50 kg starts sliding down from the top of a ski jump with a negligible friction and takes off horizontally. If h = 5 m and D = 8 m, then the skier total kinetic energy (in J) as he reaches the ground is:

a) 7500 b) 5000 c) 4100 d) 2500 e) 2500 f) Other

(c) 4100 is circled.)

$V_{0x} = V_0 \quad , \quad V_{0y} = 0$

$\Delta y = V_{0y} t + \frac{1}{2} a_y t^2 \Rightarrow -5 = 0 - 5t^2$

$t = 1 \ (s)$

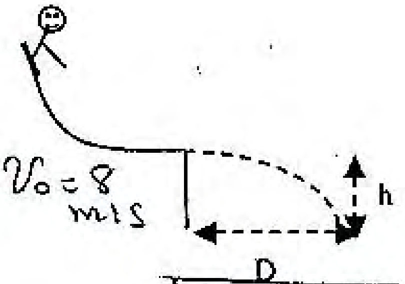
$\because \Delta x = V_0 t \Rightarrow (V_0)(1) = 8 \Rightarrow V_0 = 8 \ m/s$

$\Delta K + \Delta U = 0 \Rightarrow K = K_0 + mgh$

$= \frac{1}{2} m V_0^2 + mgh$

$= \frac{1}{2}(50)(8)^2 + (50)(10)(5) = 1600 + 2500$

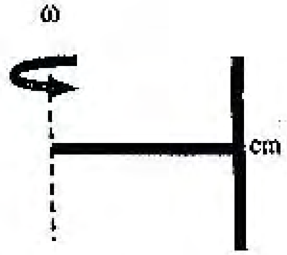
$= \boxed{4100 \ J}$



11. A rigid body consists of two equal uniform thin rods each of mass m = 2 kg and length L = 3m. The horizontal rod is attached to the center of the vertical rod. The whole system rotates at a constant speed of ω = (π/2) rad/s about a vertical axis. The angular momentum (in kg. m²/s) about that axis is:

a) 28 b) 30 c) 34 d) 38 e) 43 f) Other

(d) 38 is circled.)



$I = \left(\frac{1}{12} m l^2 + m\left(\frac{l}{2}\right)^2\right) + m l^2$

$= \frac{1}{3} m l^2 + m l^2 = \frac{4}{3} m l^2$

$I = \left(\frac{4}{3}\right)(2)(3)^2 = 24 \ kg \cdot m^2$

$L = I\omega = (24)\left(\frac{\pi}{2}\right) = 37.7 \simeq \boxed{38} \ kg \cdot m^2/s$

12. Two balls, each with mass 2 kg are connected by two rods each with length 3 meters. The rods' masses are negligible. The end of one rod is pivoted at point 0. If the system is released, then the speed (in m/s) of the ball A at the lowest point will be (ignore friction):

a) 6 b) 9 c) 11 d) 12 e) 13 f) Other

(d) 12 is circled.)

method 1

$\Delta K + \Delta U = 0$

$\left(\frac{1}{2} m V_A^2 + \frac{1}{2} m V_B^2\right) + (-mg(2l) - mgl) = 0$

$V_A^2 + V_B^2 = 6gl$

$\because \omega = \frac{V_A}{2l} = \frac{V_B}{l} \Rightarrow V_A = 2V_B$

$\therefore 5V_B^2 = 6gl$

$V_B^2 = \frac{6(10)(3)}{5} = 36 \ (m/s)^2$

$\therefore V_B = 6 \ m/s$

$\therefore V_A = 2V_B = \boxed{12 \ m/s}$

method 2

$\Delta K + \Delta U = 0$

$\frac{1}{2} I \omega^2 - 2mg\left(\frac{3}{2} l\right) = 0$

$I\omega^2 = 6mgl$

$(ml^2 + 4ml^2)\omega^2 = 6mgl$

$\therefore 5 l \omega^2 = 6gl$

$5 V_B^2 = 6gl$

$\therefore V_B^2 = \frac{6}{5}(10)(3) = 36 \ (m/s)^2$

$\because V_A = 2V_B \quad , \quad V_B = 6 \ m/s$

$\Rightarrow \therefore V_A = 12 \ m/s$