Physics 101
Summer Semester
Final Examination
Thursday, August 1, 2002
2.00-4.00 PM

Student's Name: ……… الحل النموذجي ……… Student's Number: ……………

Instructor's Name: ………………………………

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For use by instructors only

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

Notes

1. Answer all questions
2. Each question will be assigned 5 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 $g = 10 m/s^2, \cos 37 = 0.8, \sin 37 = 0.6$
7. Mobile Phones and Pagers are not allowed

P1- A block starts from rest and accelerates uniformly to 12 m/s in 2 seconds. What is the distance covered by the block during this time.

(a) 3 m $\boxed{\text{(b) 12 m}}$ (c) 24 m (d) 36 m

accelerates uniformally $\Rightarrow$ constant acceleration

$v(2) = 12\ m/s$ and $v(0) = 0$

from the first equation (1)

$$v_f = v_0 + at$$

$$a = \frac{v_f - v_0}{t} = \frac{12}{2} = 6\ m/s^2$$

from equation (3) $\Delta x = \frac{v_f^2 - v_0^2}{2a} = \frac{(12)^2 - 0}{12} = \boxed{12\ m}$ #

or eqn (4)

$$\Delta x = \tfrac{1}{2}(v_f + v_0)t = \tfrac{1}{2}(12+0)(2) = 12\ m \ \#$$

1) $v_f = v_0 + at$

2) $\Delta x = v_0 t + \frac{1}{2}at^2$

3) $v_f^2 = v_0^2 + 2a\Delta x$

4) $\Delta x = \frac{1}{2}(v_f + v_0)t$

5) $\Delta x = vt - \frac{1}{2}at^2$

P2- A particle moves in the x-y plane with a constant acceleration given by $\vec{a} = -4\hat{j}\ m/s^2$. At t=0 its position is $10\hat{i}$ and its velocity is $(-2\hat{i}+8\hat{j})$ m/s. How far is the particle from the origin at t=2 s.

(a) 23 m $\boxed{\text{b) 10 m}}$ (c) 20 m (d) 16 m

Given: $a = -4\hat{i}$ $r_0 = 10\hat{i}$ $v_0 = (-2\hat{i} + 8\hat{j})$

$$\therefore\ r = r_0 + v_0 t + \tfrac{1}{2}at^2$$

$$= 10\hat{i} + (-2\hat{i} + 8\hat{j})(2) + \tfrac{1}{2}(-4\hat{j})(2)^2$$

$$r = (10-4)\hat{i} + (16-8)\hat{j} = 6\hat{i} + 8\hat{j}$$

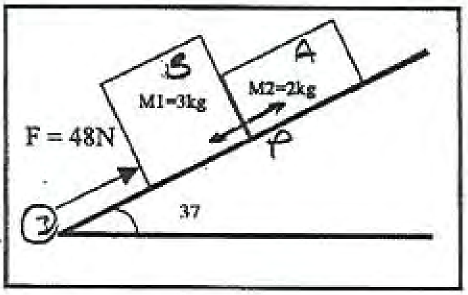
$$d = \sqrt{36+64} = 10\ m \ \#$$

P3- Two blocks having masses M_1= 2 kg and M_2=3 kg are in contact on a fixed rough inclined plane as shown in figure. A force F= 48 N accelerates the blocks up the incline. The coefficient of kinetic friction between the blocks and the incline is $\mu_k = 0.2$. The magnitude of the contact force between the blocks is

(a) 4.6 N (b) 5.6 N $\boxed{\text{(c) 19.2}}$ (d) 11.2 N

let us call the contact force between them P

analyze for both blocks A and B.



for A

(x) $P - f_k - m_A g \sin 37° = m_A a$ ---- (1)

(y) $N_A = m_A g \cos 37°$ --- (2)

for B

(x) $F - f_k - m_B g \sin 37° - m_B g \sin 37° = m_B a$ (3)

(y) $N_B = m_B g \cos 37°$ --- (4)

from (1) $P - 3.2 - 12 = 2a$ ----- (5)

and from (3) $48 - P - 4.8 - 18 = 3a$ ----- (6)

Add the two equations $\Rightarrow$ $5a = 10 \Rightarrow a = 2\ m/s^2$

$\therefore$ from eqn (5) $P = 19.2\ N$ #

P4- The only force acting on a 2-kg object varies with position as shown in figure in the form of a semi-circle. If the object starts from rest at the origin, what is the kinetic energy gained by the object during the displacement from x=0 to x=10 m.

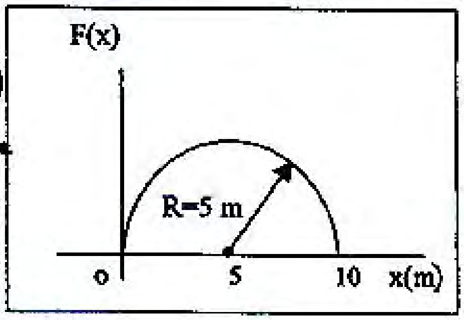
(a) 78.5 J $\boxed{\text{(b) 39.25 J}}$ (c) 31.4 J (d) 15.7 J

$W_{net} = \Delta K = K_f - K_i$

where K_i = zero (starts from rest)

$W = \int F(x)\,ds$ = area under curve

$K_f = W = \frac{\pi r^2}{2} = \frac{\pi (5)^2}{2} = \underline{39.27\ J}$



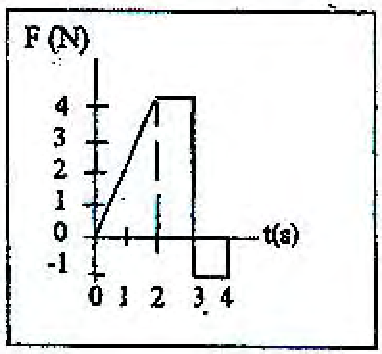
P5- The force acting on a 2- kg particle varies with time as shown in figure. Find the average force acting on the particle in the first 3 seconds.

(a) 1.33 N $\boxed{\text{(b) 2.67 N}}$ (c) 4 N (d) 12 N

$F_{avg} = \frac{J}{\Delta t} = \frac{\text{area under curve}}{\Delta t}$

$= \frac{[\frac{1}{2}(2)(4)] + [1(4)]}{3}$

$= \frac{4+4}{3} = \underline{2.67 N}$



P6- A frictionless track ABC is shown in figure. A block of mass m_1 =5 kg is released from A at height H. It makes a head-on elastic collision with a block of mass m_2=10 kg at B, initially at rest. Calculate the height H if the maximum height to which m_1 will rise after the collision is h=0.56 m.

(a) 0.28 m (b) 0.56 m (c) 3 m $\boxed{\text{(d) 5.0 m}}$

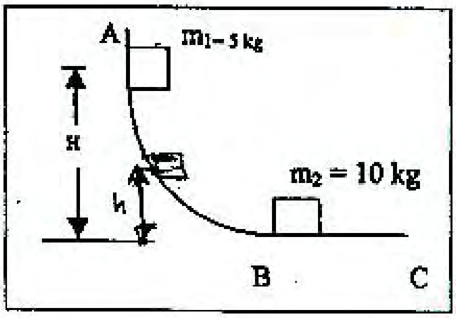
Solve the problem backward.

$m_1 g h = \frac{1}{2} m_1 v_1^2 \Rightarrow$

$v_1 = \sqrt{11.2} = 3.346\ m/s$

But v_1 here is the same for final v_{1f} of the elastic collision

$\therefore v_{1f} = \frac{m_1 - m_2}{m_1 + m_2} v_{1i} = \frac{5}{15} v_{1i}$



$\Rightarrow v_{1i} = 10\ m/s$

But v_{1i} is the same for the final velocity of the energy conservation

$m_1 g H = \frac{1}{2} m_1 v^2$

so $H = \frac{5}{2}(10)^2$..

$H = 5\ m$

P7- A 10 kg object at rest exploded into three fragments, two of them are moving after the explosion with speeds as shown. Determine the velocity of the third fragment.

(a) 54 m/s $\boxed{\text{(b) 33.6 m/s}}$ (c) 1.61 m/s (d) 19.7 m/s

$P_i = P_f$

$0 = m_1 v_1 - m_3 v_3 \cos\theta$

$0 = m_2 v_2 + m_3 v_3 \sin\theta$

$\frac{\sin\theta}{\cos\theta} = \frac{m_2 v_2}{m_1 v_1} = \frac{40}{54} = .74$

$\theta = \tan^{-1} .74 = 36.5^\circ$

$\therefore v_3 = \frac{m_1 v_1}{m_3 \cos\theta} = \frac{54}{1.61} = 35.6\, m/s$

or:

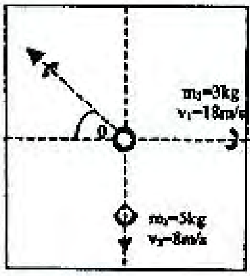
$0 = 3(18\hat{i}) - 5(8\hat{j}) + 2V_3$

$-27\hat{i} + 20\hat{j} = v_3$

$v_3 = \sqrt{(20)^2 + (27)^2}$

$= \sqrt{1129}$

$= 33.6\, m/s$



P8- A wheel rotating about a fixed axis through its center has a constant angular acceleration of 4.0 rad/s^2. In a certain 4.0 s interval the wheel turns through an angle of 80 rad. What is the angular speed of the wheel at the start of the 4.0 s interval.

(a) 28 rad/s (b) 40 rad/s (c) 16 rad/s $\boxed{\text{(d) 12 rad/s}}$

$\alpha = 4\, rad/s^2 \quad \Delta t = 4\, sec \quad \Delta\theta = 80\, rad \quad \omega_o = ??$

$\because \Delta\theta = \omega_o t + \frac{1}{2}\alpha t^2 \Rightarrow 80 = \omega_o(4) + \frac{1}{2}(4)(4)^2$

$\therefore \omega_o = \frac{80 - 32}{4} = 12\, rad/s$

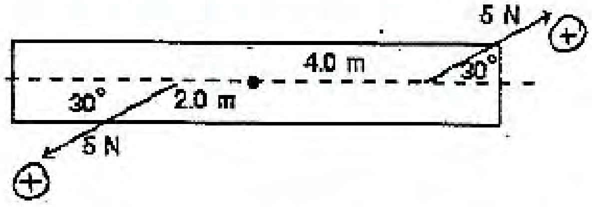
P9- A rod is pivoted about its center . A 5 N force is applied 4 m from the pivot and another 5 N force is applied 2 m from the pivot, as shown. The magnitude of the total torque is:

(a) 0 N ×m (b) 5 N ×m (c) 8.7 N ×m $\boxed{\text{(d) 15 N ×m}}$

$\tau_{net} = \tau_1 + \tau_2$

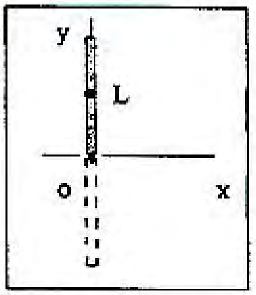
$= \oplus\, 5(4)\sin 30^\circ \oplus 5(2)\sin 30^\circ$

$= 10 + 5 = \underline{15}\, N.m$



P10 – The moment of inertia about an axis passing through the center of mass of a thin rod of mass M and length L is $I = \frac{M L^2}{12}$. If the rod is pivoted about a frictionless pin O through one end and is released from rest in a vertical position as shown in the figure. What is the linear velocity of the center of mass of the rod at the instant the rod is inverted in a vertical position

(a) $\sqrt{\frac{3g}{2L}}$ m/s (b) $\sqrt{\frac{3gL}{2}}$ m/s (c) $\sqrt{\frac{3g}{2}}$ m/s (d) $\sqrt{\frac{6g}{L}}$ m/s



$I_{cm} = \frac{ML^2}{12} \Rightarrow I = \frac{ML^2}{12} + M\frac{L^2}{4} \Rightarrow \frac{ML^2}{3}$

$\frac{1}{2} I \omega_f^2 = Mg\Delta y$. where $\Delta y = L$

$\frac{1}{2}\frac{ML^2}{3}\omega_f^2 = MgL$

$\omega_f^2 = \frac{6gL}{L^2} = \frac{6g}{L}$ --- (1)

$\because v_t = \omega_f r$ where $r = \frac{L}{2}$

$\therefore$ from (1) $v_t^2 = \frac{6g}{L}\left(\frac{L^2}{4}\right) = \frac{3gL}{2}$

$\therefore v_t = \sqrt{\frac{3gL}{2}}$ #

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P1

$$a = \frac{v - v_0}{2} = \frac{12 - 0}{2} = 6m/s^2$$

$$x = x_o + v_o t + \frac{1}{2}at^2$$

$$x = 0 + (0.5)(6)(2)^2 = 12m$$

P2

$$a = (-4i)$$

$$r_o = 10i$$

$$v_o = (-2i + 8j)$$

$$r = r_o + v_o t + \frac{1}{2}at^2 = 10i + (-2i + 8j)(2) + \frac{1}{2}(-4j)(2)^2$$

$$r = (10 - 4)i + (16 - 8)j = 6i + 8j$$

$$d = \sqrt{36 + 64} = 10m$$

P3

$$a = \frac{F - (m_1 + m_2)g\sin 37 - \mu_k(m_1 + m_2)g\cos 37}{m_1 + m_2}$$

$$a = \frac{48 - (3+2)(10)(0.6) - 0.2(3+2)(10)(0.8)}{(3+2)} = 2m/s^2$$

$$P - m_2 g\sin 37 - \mu_k m_2 g\cos 37 = m_2 a$$

$$P - (2)(10)(0.6) - (0.2)(2)(10)(0.8) = (2)(2)$$

$$P = 19.2N$$

P4

$$\Delta K = \frac{1}{2}\pi R^2 = 39.25J$$

P5

$$F_{avg} = \frac{J}{\Delta t} = \frac{area}{\Delta t} =$$

$$F_{avg} = \frac{(0.5)(2-1)(4) + (3-2)(4)}{3} = 2.67N$$

P6

$$\frac{1}{2}m_1 v^2 = m_1 g h_2$$

$$\frac{1}{2}(5)(v^2) = 5(10)(0.56)$$

$$v = \sqrt{2(10)(0.56)} = 3.33m/s$$

$$v_{1f} = \frac{(m_1 - m_2)}{(m_1 + m_2)}v_{1i}$$

$$-3.33 = \frac{(5-10)}{(5+10)}v_{1i}$$

$$v_{1i} = 10m/s$$

$$m_1 g H = \frac{1}{2}m_1 v_{1i}^2$$

$$H = (0.5)(100)/10 = 5meters$$

P7

$P_i = P_f$

$0 = m_1 v_1 - m_3 v_3 \cos\theta$

$0 = -m_2 v_2 + m_3 v_3 \sin\theta$

$$\frac{\sin\theta}{\cos\theta} = \frac{m_2 v_2}{m_1 v_1} = \frac{40}{54} = .74$$

$$\tan\theta = .74 \Rightarrow \theta = 36.5°$$

$$v_3 = \frac{m_1 v_1}{m_3\cos\theta} = \frac{54}{1.61} = 33.6m/s$$

P9

$$\tau_{net} = \tau_1 + \tau_2$$

$$\tau_{net} = |(4)(5\sin 30) + (2)(5)\sin 30| = 15N.m$$

P8

$$\Delta\theta = \omega_1\Delta t + \frac{1}{2}\alpha(\Delta t)^2$$

$$\omega_1 = \frac{80 - (0.5)(4)(4)^2}{4} = 12rad/s$$

P10

$$MgL = \frac{1}{2}\left(\frac{ML^2}{3}\right)\omega^2$$

$$\omega = \sqrt{\frac{6g}{L}}$$

$$v_{com} = \omega\left(\frac{L}{2}\right) = \sqrt{\frac{3gL}{2}}$$