Kuwait University **Physics Department**

Physics 101
Summer Semester
Second Midterm Examination
Saturday, July 27, 2002
5-7 PM

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

Instructor's Name: ....

Dr. Abdulnasser **Abu-Rezq**, Dr. Adnan **Al-Yaseen**
Dr. Ahmad **Tolba**, Dr. Hassan **Raafat** Dr. Yacob **Makdisi**.

For use by instructors only

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

Notes

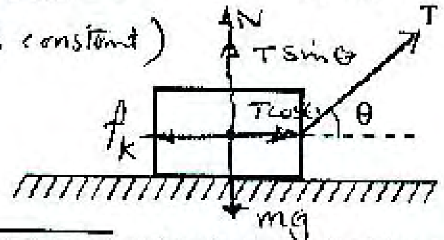
1. Answer all questions
2. Each question will be assigned 2 points
3. The solution should be given explicitly for each problem
4. No solution = no points
5. Check the correct answer for each question
6. Take $g = 10 m/s^2, \cos 37 = 0.8, \sin 37 = 0.6$
7. Mobile Phones and Pagers are not allowed

P1- A block of mass m is pulled at constant velocity along a rough horizontal floor by an applied force T as shown. The magnitude of the frictional force is:

(a) mg (b) Tsin θ **[(c) T cos θ]** (d) mg cos θ

(x) $T\cos\theta - f_k = m(0)$ (for v is constant)

$\therefore f_k = T\cos\theta$ #



P2- A pilot of mass 80 kg executes a looping-the-loop maneuver and makes a vertical loop of 3000 m radius with a speed of 400 km/h. Determine the magnitude of the force exerted by the seat on the pilot at the <u>bottom</u> of the loop.

[(a) 1129 N] (b) 471 N (c) 329 N (d) zero

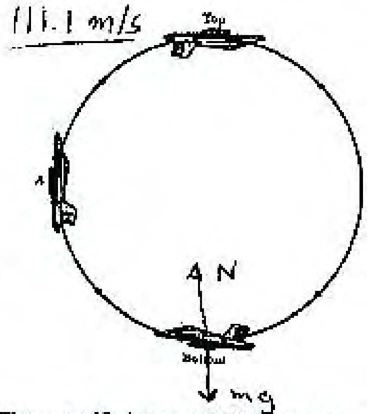
Given: $r = 3000$, $v = 400 = \frac{400 \times 1000}{3600} = 111.1$ m/s

forces at the bottom:

$-N + mg = m\left(\frac{-v^2}{r}\right)$

$N = m\left(\frac{v^2}{r} + g\right)$

$N = 80\left(\frac{(111)^2}{3000} + 10\right) = 1129.2$ N #



P3- Block A, with a mass of 50 kg, rests on a horizontal table top. The coefficients of friction are $\mu_s = 0.4$ and $\mu_k = 0.2$. A horizontal string is attached to A and passes over a massless, frictionless pulley as shown in the figure. The smallest mass of block B that will start A moving when it is attached to the other end of the string is:

(a) 50 kg (b) 10 kg (c) 40 kg **[(d) 20 kg]**

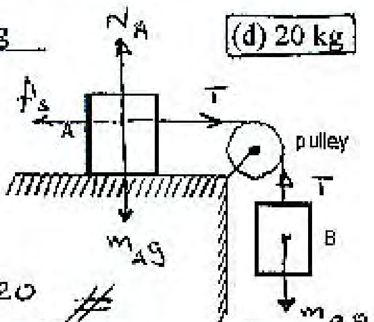
for m_B: $T = m_B g$ ---- (1)

for m_A: (x) $T - f_s = 0$ --- (2)

(y) $N = m_A g$ --- (3)

from eq. (1) and (2) and (3)

$m_B(10) - (.4)(50)(10) = 0 \Rightarrow m_B = 20$ #



P4- Camping equipment weighing 6000 N is pulled across a frozen lake by means of a rope making an angle $\theta = 37°$ with the horizontal. The coefficient of kinetic friction is 0.05. The work done by the campers in pulling the equipment 1000 m at constant velocity is:

(a) 3.1×10^4 J (b) 1.5×10^5 J (c) 3.6×10^5 J **[(d) 2.89×10^5 J]**

Constant velocity means equal forces on the x-axis

$\therefore$ (y) $N + T\sin\theta - mg = 0$

$N = mg - T\sin\theta$

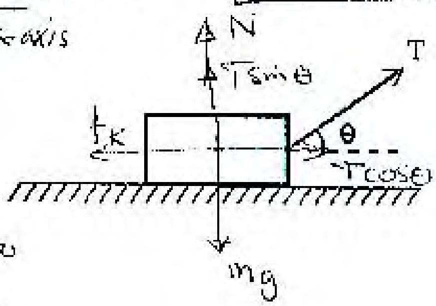
(x) $T\cos\theta - f_k = 0$

$T\cos\theta - \mu_k(mg - T\sin\theta) = 0$

$T(\cos\theta + \mu_k \sin\theta) = \mu_k mg$

$T(.8 + (.05)(.6)) = (.05)(6000) \Rightarrow T(.83) = (300)$

$T = \frac{300}{.83} = 361.445$ N



$\therefore W = \vec{F} \cdot \vec{d} = (361.445)(1000)(\cos\theta) = 2.89 \times 10^5$ J

P5- If an applied force varies with position according to $F(x) = 4x^3 - 5$ N, where x is in m, how much work is done by this force on an object that moves from x =2 m to x =3 m?

(a) 70 J (b) 65 J m (c) 135 J **(d) 60 J**

$$W = \int_{x_i}^{x_f} F(x)\,dx = \int_2^3 4x^3 - 5\,dx$$

$$= \left[x^4 - 5x\right]_2^3 = \left[x^4\right]_2^3 - \left[5x\right]_2^3$$

$$= \left[3^4 - 2^4\right] - 5\left[3 - 2\right] = \left[81 - 16\right] - \left[5\right]$$

$$= 60\ \text{J}\ //$$

P6- A 65-kg man runs a distance of 600 m up a mountain inclined at 20 degrees to the horizontal. Assuming running with constant speed, the average power output during the 80 s run time is

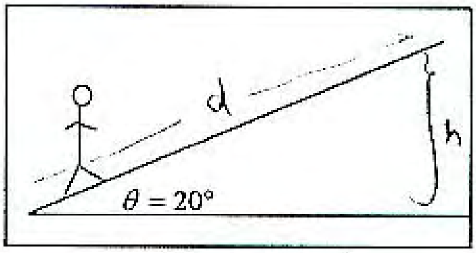
(a) 1.67 kW (b) 131 kW (c) 39 kW (d) 1.31 kW

$$P_{avg} = \frac{W}{\Delta t} = \frac{mgh}{80}$$

$$= \frac{mg\,(d \sin\theta)}{80}$$

$$= 1667.3$$

$$= 1.67 \times 10^3\ \text{W}$$



$$\sin\theta = \frac{h}{d}$$

$$h = d\sin\theta$$

P7- In a given displacement of a block on a rough surface, its kinetic energy increases by 25 J while its potential energy decreases by 40 J. Determine the thermal energy gained by both the block and the surface during this displacement.

(a) 50J (b) 35 J **(c) 15 J** (d) 35 J

$$\because\ \Delta E_{mec} + \Delta E_{th} = 0$$

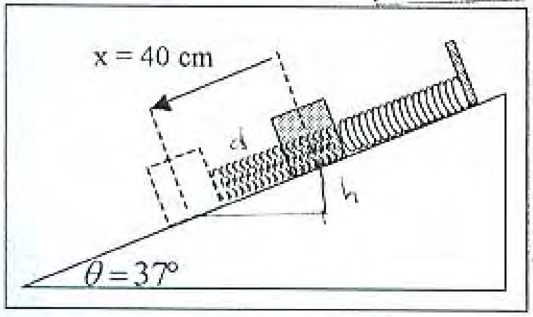
$$\text{or}\quad \Delta K + \Delta U + \Delta E_{th} = 0$$

$$\therefore\ +25 - 40 + \Delta E_{th} = 0$$

$$\therefore\ \Delta E_{th} = 15\ \text{J}\ //$$

P8- A spring of constant k=400 N/m is attached to a mass m = 40-kg. The block is held such that the spring is relaxed. When the block is released from rest it slides down the inclined frictionless surface. Find the velocity of the block when the spring expansion is 40 cm.

(a) 3.6 m/s (b) 3.6 m/s (c) 1.4 m/s (d) 1.8 m/s



$\Delta E_{mec} = 0$

$E_f = E_i$

$\frac{1}{2} m v^2 + \frac{1}{2} K x^2 = mgh$

$\frac{1}{2}(40)v^2 + \frac{1}{2}(400)(.4)^2 = (40)(10)(.24)$

$20v^2 + 32 = 96$

$v^2 = \frac{64}{20} = 3.2$

$v = 1.79$ m/s #

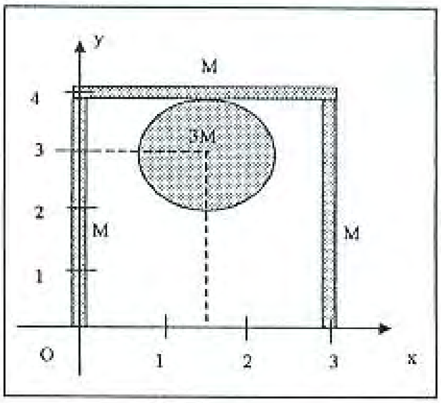
$\sin\theta = \frac{h}{d}$

$h = d \sin\theta$

$h = (.4)(.6) = .24$ m

P9- The configuration shown in figure includes three thin rods of masses M, M and M and a disk with mass 3M. If the rods and the disk are made of the same material, the coordinates of thee center of mass of the configuration relative to the origin O are

(a) (1.50 , 2.00) (b) (1.50 , 2.83) (c) (1.0 , 2.0) (d) (3.0, 2.0)



$x_{cm} = \frac{M(0) + M(3) + M(1.5) + 3M(1.5)}{M + M + M + 3M}$

$= \frac{9}{6} = 1.5$

$y_{cm} = \frac{M(2) + M(2) + M(4) + 3M(3)}{6M}$

$= \frac{17}{6} = 2.83$

P10- A 2-kg particle has a velocity of (2i-3j) m/s, and a 3-kg particle has a velocity of (i+6j) m/s. Find the velocity of the center of mass of the system

(a) (7i + 12 j) m/s (b) (1.4i+2.4j) m/s (c) (3.5i+6j) m/s (c) (7i-12j) m/s

$V_{cm} = \frac{P_i}{M} = \frac{m_1 v_{1i} + m_2 v_{2i}}{m_1 + m_2} =$

$= \frac{2(2\hat{i} - 3\hat{j}) + 3(\hat{i} + 6\hat{j})}{2+3} = \frac{7\hat{i} + 12\hat{j}}{5} =$

$= (1.4\hat{i} + 2.4\hat{j})$ m/s

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(P1)

$$T\cos\theta - f_k = 0$$
$$f_k = T\cos\theta$$

(P2)
$$N - mg = m\frac{v^2}{r}$$
$$N = mg + m\frac{v^2}{r} = (80)(10) + (80)(400\times 1000/3600)^2/3000 = 1129.2(N)$$

(P3)

$$m_B g - \mu_s m_A g = 0$$
$$m_B =_s m_A$$
$$m_B = (0.4)(50) = 20kg$$

(P4)
$$W_c = -W_{f_k}$$
$$W_c = \mu_k(mg - T\sin\theta)d$$
$$T\cos\theta - \mu_k(mg - T\sin\theta) = 0$$
$$T = \frac{\mu_k mg}{\cos\theta + \mu_k\sin\theta} = \frac{0.05(6000)}{0.8 + (0.05)(0.6)} = 361.445$$
$$W_c = 361.445(0.8)(1000) = 289.16\times 10^3 J$$

P5
$$W = \int_{x_i=2}^{x_f=3}(4x^3 - 5)dx = [4\frac{x^4}{4} - 5x]_2^3 = [x^4]_2^3 - 5[x]_2^3 = [3^4 - 2^4] - 5[3-2] = (81-16) - (5)(1) = 60J$$

(P6)
$$W_{net} = W_g + W_{man} = \Delta K = 0$$
$$W_{man} = -W_g = -(-mgh) = mgd\sin\theta$$
$$\bar{P} = \frac{W}{\Delta t} = \frac{mgd\sin\theta}{\Delta t} = \frac{(65)(10)(600)(0.342)}{80} = 1.67kW$$

(P7)

$$E_{th} = |W_f| = \Delta U_g + \Delta K = -15 + 25 = 15J$$

(P8)
$$mgh = \frac{1}{2}kx^2 + \frac{1}{2}mv^2$$
$$(40)(10)(0.4)(0.6) = (0.5)(400)(0.4)^2 + (0.5)(40)(v^2)$$
$$v = 1.79m/s^2$$

(P9)
$$x_{com} = \frac{M(0) + M(3) + M(1.5) + 3M(1.5)}{M + M + M + 3M} = \frac{9}{6} = 1.5$$
$$y_{com} = \frac{M(2) + M(2) + M(4) + 3M(3)}{M + M + M + 3M} = \frac{17}{6} = 2.83$$

(P10)
$$V_{com} = \frac{P}{M} = \frac{m_1 v_1 + m_2 v_2}{m_1 + m_2} = \frac{2(2i - 3j) + 3(i + 6j)}{2+3} = \frac{7i + 12j}{5} = (1.4i + 2.4j)m/s$$