UNIVERSITY OF GAZIANTEP
DEPARTMENT OF ENGINEERING PHYSICS
EP 105 General Physics I
First Midterm Exam *FALL 2019*

Date: 07/11/2019 Time: 10:30 Duration: 90 min.

Ques.	Mark
1	
2	
3	
4	
5	
Total	

DEPARTMENT : CE ☐ MME ☐ IE ☐ ME ☐ TE ☐

Name	Surname	Student No	Signature
—	SOLUTIONS	—	

- Cheating is a serious offence and may lead to your dismissal from the university.
- Ignore air resistance in all problems unless otherwise stated.
- Write clearly your solutions steps to the space provided and results to the boxes.
- Constants: $g = 9.8\ m/s^2$, $\pi = 3.141593$
- Conversions: $1\ g = 10^{-3}$ kg, $1\ cm = 10^{-2}$ m, $1\ km = 10^3$ m, 1 h = 3600 s, 1 min = 60 s, 1 rev = 2π rad.

QUESTION 1 (20 %)

A particle moves on the x-y plane. The position vector of the particle is given by

$$\vec{r}(t) = (t\text{-}10)\,\mathbf{i} + 2t\,\mathbf{j}\ \ (\text{m})$$

where t is the time in seconds.

(a) Find the displacement vector of the particle between $t = 0$ and $t = 5$ s.

$$\vec{r}(5) = (5-10)\hat{i} + 2(5)\hat{j} = -5\hat{i} + 10\hat{j}\ (m)$$

$$\vec{r}(0) = (0-10)\hat{i} + 2(0)\hat{j} = -10\hat{i}\ (m)$$

$$\Delta\vec{r} = \vec{r}(5) - \vec{r}(0) = -5\hat{i} + 10\hat{j} - (-10\hat{i}) \Rightarrow$$

$$\boxed{\Delta\vec{r} = 5\hat{i} + 10\hat{j}\ (m)}$$

(b) Find the instantaneous velocity vector, $\vec{v}$, of the particle at time $t = 5$ s.

$$\vec{v}(t) = \frac{d\vec{r}}{dt} = \frac{d}{dt}\left\{(t-10)\hat{i} + 2t\hat{j}\right\}$$

$$= \hat{i} + 2\hat{j}\ (m/s)$$

$$\vec{v}(5) = \hat{i} + 2\hat{j}\ (m/s)$$

$$\boxed{\vec{v} = \hat{i} + 2\hat{j}\ (m/s)}$$

(c) What is the position vector of particle at a time corresponding to $\vec{r} \cdot \vec{v} = 0$?

$$\vec{r} \cdot \vec{v} = \left[(t-10)\hat{i} + 2t\hat{j}\right] \cdot \left[\hat{i} + 2\hat{j}\right] = 0$$

$$= t - 10 + 4t = 0 \Rightarrow t = 2s.$$

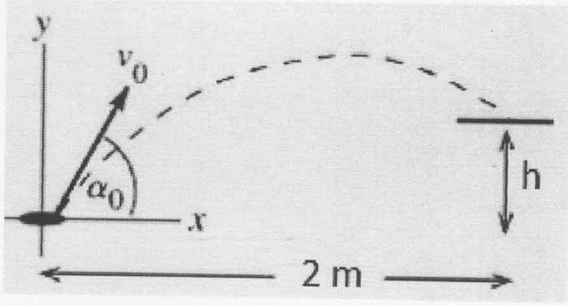
$$\vec{r}(2) = (2-10)\hat{i} + 2(2)\hat{j}$$

$$= -8\hat{i} + 4\hat{j}\ (m)$$

$$\boxed{\vec{r} = -8\hat{i} + 4\hat{j}\ (m)}$$

QUESTION 2 (20 %)

An object is thrown from ground into the air with an initial speed $V_0 = 5\ m/s$ and an angle of $\alpha_0 = 60^0$. If its height is h when it reaches a horizontal distance of $2\ m$, find



(a) the components of the initial velocity of object,

$$V_{ox} = V_0 \cos\alpha_0 = 5 \cos 60^\circ = 2.5\ m/s$$

$$V_{oy} = V_0 \sin\alpha_0 = 5 \sin 60^\circ = 4.33\ m/s$$

$V_{ox} = 2.50\ m/s$

$V_{oy} = 4.33\ m/s$

(b) the time to reach this height,

$$x = v_{ox} t \rightarrow t = \frac{x}{v_{ox}} = \frac{2}{2.5} = 0.8\ s$$

$t = 0.8 s$

(c) the height h, and

$$y = h = v_{oy} t - \frac{1}{2} g t^2$$
$$= (4.33)(0.8) - \frac{1}{2}(9.8)(0.8)^2$$
$$= 0.34\ m$$

$h = 0.34 m$

(d) the components of velocity at this height.

$$V_x = V_{ox} = 2.5\ m/s$$

$$V_y = V_{oy} - g t$$
$$= 4.33 - (9.8)(0.8)$$
$$= -3.5\ m/s$$

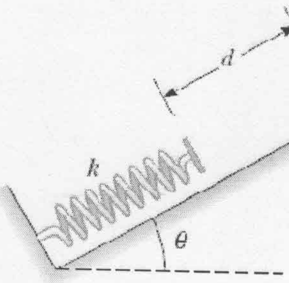
$V_x = 2.5\ m/s$

$V_y = -3.5\ m/s$

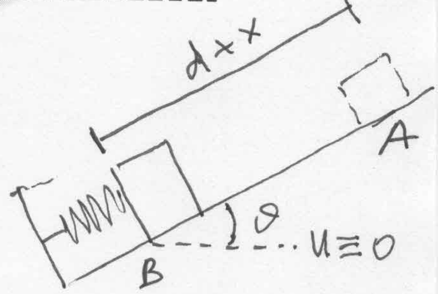
QUESTION 3 (20 %)

An object of mass $m=3\ kg$ starts from rest and slides a distance d down a frictionless incline of angle $\theta=30^o$. While sliding, it contacts an unstressed spring of negligible mass as shown in the figure. The object slides an additional distance $x=0.2\ m$ as it is brought momentarily to rest by compression of the spring (of force constant $k=400\ N/m$). Using the conservation of mechanical energy, find the initial separation d between object and spring.

Hint: *Choose the zero point of gravitational potential energy of the object-spring-Earth system as the configuration in which the object comes to rest.*



we can choose $U_g = 0$ in which the object comes to rest. Since there is no friction, $E_A = E_B$.



$$K_B + U_{gB} + U_{sB} = K_A + U_{gA} + U_{sA}$$

$$0 + mg(d+x)\sin\theta + 0 = 0 + 0 + \frac{1}{2}kx^2$$

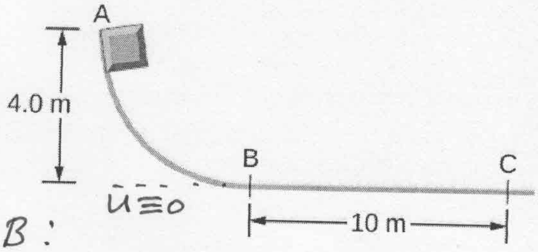
or $$d = \frac{kx^2}{2mg\sin\theta} - x = 0.34\ m$$

$$\boxed{d = 0.34\ m}$$

QUESTION 4 (20 %)

A small block of mass 240 g starts at rest at point A, slides to point B where its speed is $v_B = 7$ m/s. Then it slides along the horizontal surface a distance of 10 m before coming to rest at point C.

(a) What is the work done by friction along the curved surface?



Work done by friction along curve A-B:

$m = 0.24\ kg$
$h = 4\ m$
$v_B = 7\ m/s$
$d = 10\ m$

$$W_f = \Delta E$$
$$= E_B - E_A$$
$$= \frac{1}{2}mv_B^2 - mgh$$
$$= \frac{1}{2}(0.24)(7)^2 - (0.24)(9.8)(4)$$
$$= -3.5\ J$$

$$\boxed{W_f = -3.5\ J}$$

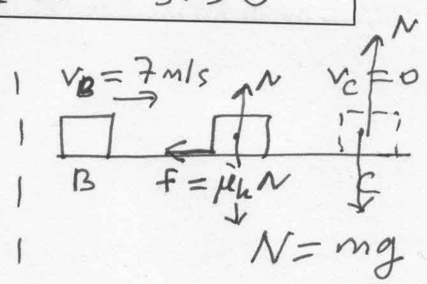
(b) What is the coefficient of kinetic friction along the horizontal surface?

method I

$$W_f = E_C - E_B$$
$$-fd = 0 - \frac{1}{2}mv_B^2$$
$$-\mu_k mgd = -\frac{1}{2}mv_B^2$$
$$\mu_k = \frac{v_B^2}{2gd}$$
$$= \frac{7^2}{(2)(9.8)(10)} = 0.25$$

method II

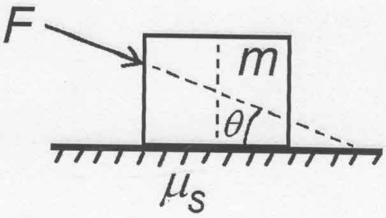
eqn. of motion:
$$v_C^2 = v_B^2 - 2ad$$
$$a = v_B^2/2d$$
$$F_{net} = ma$$
$$f = ma$$
$$\mu_k mg = m\left(\frac{v_B^2}{2d}\right)$$
$$\mu_k = \frac{v_B^2}{2gd} = 0.25$$



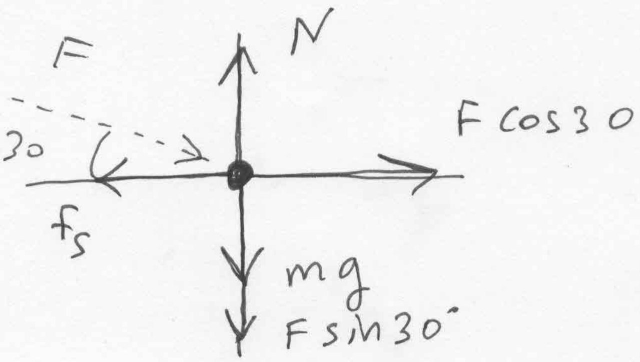
$$\boxed{\mu_k = 0.25}$$

QUESTION 5 (20 %)

A block of mass $m = 12$ kg is pushed with a force F at an angle of $\theta = 30^{\circ}$ on a horizontal floor that has a coefficient of static friction $\mu_S = 0.3$ as shown in Figure.



(a) Show all forces acting on the object (Namely, draw the free-body diagram of the system).



$m = 12$ kg

$\theta = 30^{\circ}$

$\mu_s = 0.3$

$f_s = \mu_s N$

$= \mu_s (mg + F\sin\theta)$

(b) What minimum value of force, F is required to move the block?

Newton's 2nd law:

$F\cos 30 - f_s = ma = 0$ ← since the block is at rest

$F\cos 30^{\circ} - \mu_s (mg + F\sin\theta) = 0$

Solving for F:

$$F = \frac{\mu_s mg}{\cos\theta - \mu_s \sin\theta} = \frac{(0.3)(12)(9.8)}{\cos 30 - (0.3)\sin 30^{\circ}}$$

$= 49.3\ N$

This is the minimum value.

$F = 49.3\ N$

$\therefore\ F \geq 49.3\ N$ to move the block.