Kuwait University Physics Department

Physics 101

Summer Semester

Second Midterm Exam

Saturday, August 6, 2022

9:00 AM – 10:30 AM

Student's Name: …………………………………………………………. Serial Number: ……………

Student's Number: ………………………………………………………. Section: ……………………

Choose your Instructor's Name:

Dr. Fatema Aldossari Dr. Belal Salameh

Dr. Abdul Khaleq

For Instructors use only

Grades:

#	SP1	SP2	SP3	SP4	SP5	SP6	LP1	LP2	Q1	Q2	Q3	Q4	Q5	Total
Pts	2	2	2	2	2	2	4	4	1	1	1	1	1	25

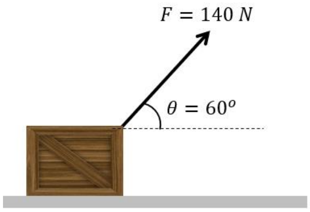
Important:

1. Answer all questions and problems (No solution = no points).
2. Full mark = 25 points as arranged in the above table.
3. **Give your final answer in the correct units.**
4. Assume $g = 10\ m/s^2$.
5. Mobiles are **<u>strictly prohibited</u>** during the exam.
6. Programmable calculators, which can store equations, are not allowed.
7. **Cheating incidents will be processed according to the university rules.**

GOOD LUCK

Part I: Short Problems (2 points each)

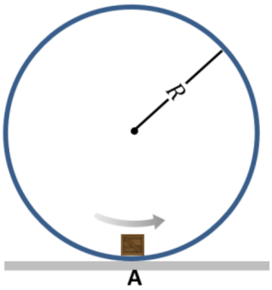
SP1. A block of mass ($M = 35\ kg$) rests on a **frictionless surface.** A constant force ($F = 140\ N$) is applied to the block at an angle $\theta = 60°$ with the horizontal, as shown. **Find the magnitude of the block's acceleration.**



$$F \cos 60^o = ma$$

$$a = \frac{F \cos 60^o}{m} = 2 m/s^2$$

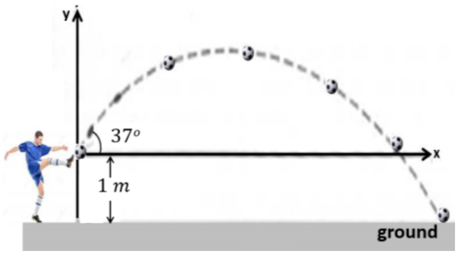
SP2. A vertical hoop of radius (R) is fixed to the ground. A small block of mass $m = 0.2\ kg$ is sliding along the inside surface of the hoop **without friction**, as shown. At the **lowest point (point A)**, the block has a speed $v_A = 2\ m/s$ and the normal force on it from the hoop is $n_A = 4\ N$. **Find the radius R of the hoop.**



$$n_A - mg = m\frac{v_A^2}{R}$$

$$R = \frac{mv_A^2}{n_A - mg} = 0.4\ m$$

SP3. A football player kicked a ball with an initial speed $v_i = 20\ m/s$ at an angle 37° above the horizontal. The ball left his foot at **a height of 1 m above the ground**, as shown. **Find the speed of the ball just before it hits the ground.**



$$v_{x_i} = v_i \cos\theta = 20 \cos 37^o = 16\ m/s$$

$$v_{y_i} = v_i \sin\theta = 20 \sin 37^o = 12\ m/s$$

$$v_{y_f}^2 = v_{y_i}^2 - 2g\Delta y = 12^2 - 20\,(-1) = 164$$

$$v_{y_f} = -12.8\ m/s$$

$$v_{x_f} = v_{x_i} = 16\ m/s$$

$$v_f = \sqrt{-12.8^2 + 16^2} = 20.5\ m/s$$

SP4. A block of mass $m = 2\,Kg$ is initially at **rest** at $\boldsymbol{x = 0\,m}$ on a **horizontal frictionless surface.** A horizontal force along the $x - axis$, $F(x) = 4 + 3x^2$ where x is in m, is applied to the block. **Use the work energy theorem to find the speed of the block as it passes through $\boldsymbol{x = 2\,m}$.**

$$w_{total} = \Delta K$$

$$\int_{x_i}^{x_f} F(x)\,dx = \frac{1}{2}m(v_f^2 - v_i^2)$$

$$\int_{x_i}^{x_f} (4 + 3x^2)dx = [4x + x^3]_0^2 = \frac{1}{2}(2)(v_f^2 - 0) \Rightarrow v_f = 4\,m/s$$

SP5. The figure shows a block of mass $m = 2\,kg$ moving on a horizontal **rough surface** ($\mu_k = 0.3$) and an uncompressed spring ($k = 1500\,N/m$) with one end attached to a wall. The speed of the block **before it touches the spring** is $4\,m/s$. **Find the speed of the block at the instant the spring has been compressed $\boldsymbol{x = 0.12\,m}$.**

$$w_{total} = \Delta K$$

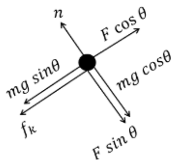
$$w_{F_s} + w_{f_k} = \Delta K$$

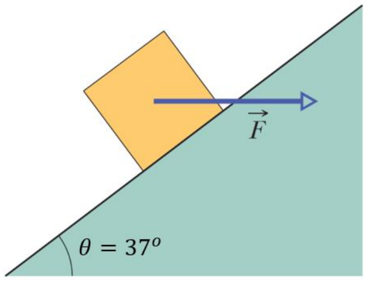
$$\frac{1}{2}k\left(x_i^2 - x_f^2\right) - \mu_k mgd = \frac{1}{2}m(v_f^2 - v_i^2)$$

$$\frac{1}{2}(1500)(0 - 0.12^2) - (0.3)(20)(0.12) = \frac{1}{2}(2)(v_f^2 - 4^2)$$

$$v_f = 2.1\,m/s$$

SP6. A 2 kg block **starts from rest and <u>slides up</u>** a rough incline ($\mu_k = 0.5$) while **a horizontal force** ($F = 50\,N$) acts on it, as shown. **Find the acceleration of the block.**





$$n = F\sin\theta + mg\cos\theta = 46.1\,N$$

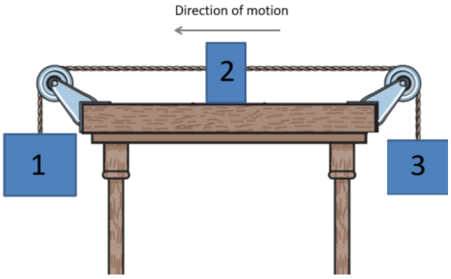
$$F\cos\theta - mg\sin\theta - f_k = ma$$

$$F\cos\theta - mg\sin\theta - \mu_k n = ma$$

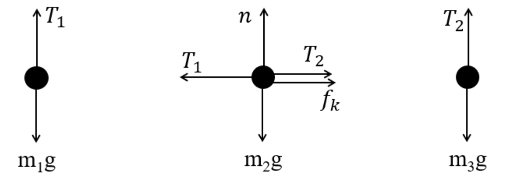
$$a = \frac{F\cos\theta - mg\sin\theta - \mu_k n}{m} = 2.4\,m/s^2$$

Part II: Long Problems (4 points each)

LP1. Three blocks ($m_1 = 3.5\ Kg, m_2 = 1\ Kg, m_3 = 2.5\ Kg$) are connected by two ropes and block 2 moves to the left on **a rough table** ($\mu_k = 0.3$), as shown. The pulleys are frictionless and massless.



a) Plot a free-body diagram for each block.



For m_1 For m_2 For m_3

b) Find the acceleration of the system.

For $\boldsymbol{m_{total}}$

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

$$a = \frac{m_1 g - \mu_k m_2 g - m_2 g}{m_1 + m_2 + m_3} = 1 m/s^2$$

c) Find the tension in each of the two ropes (T_1 and T_2).

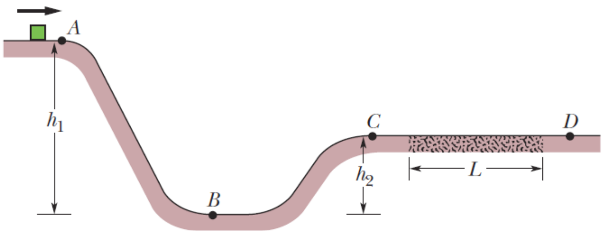
For $\boldsymbol{m_1}$

$$m_1 g - T_1 = m_1 a \Rightarrow T_1 = m_1(g - a) = 31.5\ N$$

For $\boldsymbol{m_2}$

$$T_2 - m_2 g = m_2 a \Rightarrow T_2 = m_2(g + a) = 27.5\ N$$

LP2 A small block of mass $m = 0.4\ Kg$ is sent through point A with a speed of $7\ m/s$. Its path is frictionless until it reaches the section of length $L = 12\ m$, where the coefficient of kinetic friction is $\mu_k = 0.7$. The indicated heights are $h_1 = 6\ m$ and $h_2 = 2\ m$.



a) Find the work done by the gravitational force during the displacement from A to B.

$$w_{mg} = +mgh_1 = +0.4(10)(6) = +24\ J$$

b) Find the speed of the block at point C.

$$\sum w = \Delta K$$

$$w_{mg} = K_C - K_A$$

$$mg(h_1 - h_2) = \frac{1}{2}m(v_C^2 - v_A^2)$$

$$16 = \frac{1}{2}(0.4)(v_C^2 - 7^2) \Rightarrow v_C = 11.4\ m/s$$

c) Does the block reach point D? If so, what is its speed there; if not, how far through the rough section does it travel?

$$|w_{f_k}|_{for\ the\ length\ \boldsymbol{L}} = \mu_k mgL = 0.7(4)(12) = 33.6\ J$$

$$K_C = \frac{1}{2}mv_C^2 = 25.8\ J$$

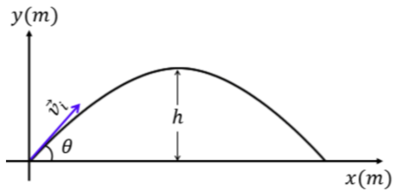
Since $K_C < |w_{f_k}|$ then the block will not reach point D, it will reach a point at distance **d** from the first edge of the rough portion and stops there.

$$K_C = |w_{f_k}|_{for\ the\ length\ \boldsymbol{d}}$$

$$25.8\ J = \mu_k mgL = 0.7(4)(d) \Rightarrow d = 9.2\ m$$

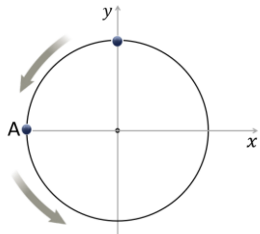
Part III: Questions (Choose the correct answer, one point each)

Q1. A ball of mass $m = 0.15\ kg$ is thrown at an angle of $\theta = 45°$ above the horizontal with an initial speed of $v_i = 12\ m/s$. **At its highest point, the net force on it is:**



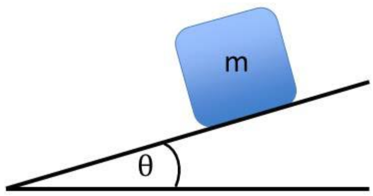
* zero
* 10 N, up
* 10 N, down
* 1.5 N, down

Q2. A particle moves **contraclockwise** with constant speed (v) around the circle of radius (r), as shown. When it is at point A, **its velocity** $(\vec{v})$ **and acceleration** $(\vec{a})$ **are**:



* $\vec{v} = v\hat{\imath}\ ,\ \vec{a} = \frac{v^2}{r}\hat{\imath}$
* $\vec{v} = -v\hat{\jmath}\ ,\ \vec{a} = \frac{v^2}{r}\hat{\imath}$
* $\vec{v} = -v\hat{\jmath}\ ,\ \vec{a} = -\frac{v^2}{r}\hat{\imath}$
* $\vec{v} = v\hat{\jmath}\ ,\ \vec{a} = -\frac{v^2}{r}\hat{\imath}$

Q3. A block of mass m is at **rest** on an incline that makes an angle θ with the horizontal, as shown. **Which of the following statements about the magnitude of the static friction force is true?**

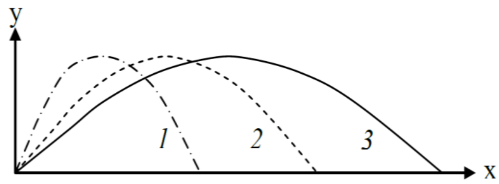


* $f_s = mgcos\theta$
* $f_s < mgsin\theta$
* $f_s = mgsin\theta$
* $f_s > mgsin\theta$

Q4. Which of the following **forces always produce zero work**?

* radial force $(\vec{F}_r)$ in a circular motion
* tangential force $(\vec{F}_T)$ in the circular motion
* static frictional force $(\vec{f}_s)$
* normal force $(\vec{n})$

Q5. The figure shows the trajectories of three projectiles. **Which trajectory has the greatest initial vertical component of velocity (V_{yi}).**



* 1
* 2
* 3
* All the same