Kuwait University **Physics Department**

Physics 101

Fall Semester

Second Midterm Exam

Saturday, February 6, 2021

9:00 am – 11:00 am

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

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

Choose your Instructor's Name:

Dr. Ahmed Al-Jassar
Dr. Hala Al-Jassar
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Dr. Tareq Al Refai
Dr. Belal Salameh
Dr. Abdel Khaleq

For Instructors use only

#	Q1	Q2	Q3	Q4	Q5	SP1	SP2	SP3	SP4	SP5	SP6	SP7	SP8	SP9	LP1	LP2	LP3	Total
Pts	2	2	2	2	2	2	2	2	2	2	2	2	2	2	4	4	4	**40**

Important:

1. Answer all questions and problems.
2. Full mark = 40 points as arranged in the above table.
   i) 5 <u>Q</u>uestions
   ii) 9 <u>S</u>hort <u>P</u>roblems
   iii) 3 <u>L</u>ong <u>P</u>roblems
3. No solution = no points.
4. **Use SI units.**
5. Check the correct answer for each question.
6. Assume g = 10 m/s^2.
7. Mobiles are **<u>strictly prohibited</u>** during the exam.
8. Programmable calculators, which can store equations, are not allowed.
9. **Cheating incidents will be processed according to the university rules.**

GOOD LUCK

Part I: Questions (Choose the correct answer, 2 points each)

Q1. A box is accelerated by a force of 100 N. After 10 s, a second force of 100 N is exerted on the box in the opposite direction, so that **the two forces cancel each other**, **then the box**

* is brought to rest immediately.

* is brought to rest within 10 s.

* will continue to move with decreasing speed.

* will continue to move with constant speed.

Q2. In a uniform circular motion, **the vectors that point toward the center of the circular path are:**

* acceleration and net force.

* velocity and acceleration.

* velocity and net force.

* velocity, acceleration, and net force.

Q3. A man pushes a block up an incline at **constant speed**. The block's kinetic energy is **K** and the potential energy is **U. As the block moves up the incline,**

* Both **K** and **U** increase.

* **K** increases and **U** remains the same.

* **K** remains the same and **U** increases.

* **K** decreases and **U** increases.

Q4. A 60 kg student is standing on a scale in an elevator. If the scale reads 650 N, then the elevator is:

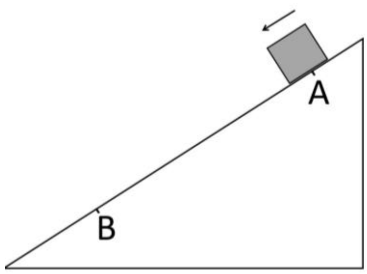
* moving downward with increasing speed.

* moving downward with decreasing speed.

* moving upward with decreasing speed.

* moving upward with constant speed.

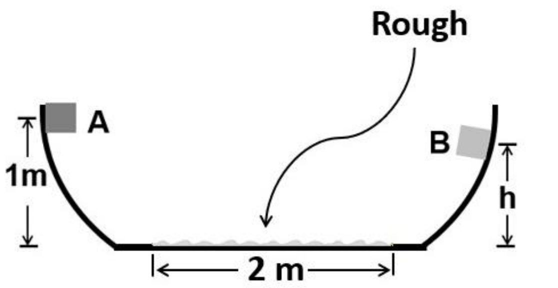
Q5. A block slides along **a rough incline**. Its total mechanical energy (E) and potential energy (U) respectively at point A are (70 J and 50 J) and at point B are (40 J and 40 J). **The work done by the frictional force on the block between points A and B is:**



* -10 * $-20\,J$ * $-30\,J$ * $-40\,J$

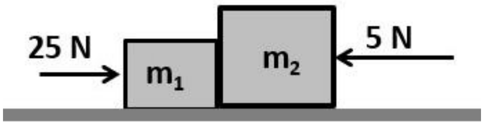
Part II: Short Problems (2 points each)

SP1. A 2 kg block is released **from rest** at point A and slides on the shown track. The track is frictionless except a portion from the **flat part which is rough** ($\mu_k = 0.2$). **If the block stops momentarily at point B, find the value of h.**



$$E_f - E_i = -\mu_k mgd$$
$$mgh - mg(1) = -\mu_k mgd$$
$$h = 1 - \mu_k d = 1 - (0.2)(2) = 0.6\, m$$

SP2. In the shown figure, if $m_1 = 3\,kg, m_2 = 2\,kg$ and the horizontal surface is frictionless, **find the magnitude of the force exerted on block 1 by block 2 (F_{21}).**



$$\vec{a} = \frac{\sum \vec{F}}{m_1 + m_2} = \frac{+20\,\hat{\imath}}{5} = +4\,\hat{\imath}\,m/s^2$$

$$25 - F_{21} = m_1 a = 12 \quad \Rightarrow \quad F_{21} = 13\,N$$

SP3. A box of mass $m = 32\,kg$ rests on the bed of a truck. If the coefficients of friction between the box and the truck's bed are ($\mu_s = 0.4$ and $\mu_k = 0.3$). **Find the minimum acceleration of the truck so the box slides.**

$$ma_{min} = f_{s_{max}} = \mu_s mg$$
$$a_{min} = \mu_s g = 4\,m/s^2$$

SP4. A box moves on **a frictionless horizontal surface** under the influence of the two forces $\vec{F}_1 = (50\hat{\imath} + 60\hat{\jmath})\ N, \overrightarrow{F_2} = (120\hat{\imath} + 80\hat{\jmath})\ N$. **Find the total power delivered to the block when its velocity is $\vec{v} = (5\hat{\imath} + 3\hat{\jmath})\ m/s$.**

$\vec{F}_{net} = \vec{F}_1 + \overrightarrow{F_2} = (170\hat{\imath} + 140\hat{\jmath})\ N$

$P = \vec{F}_{net} \cdot \vec{v} = 170(5) + 140(3) = 1270\ W$

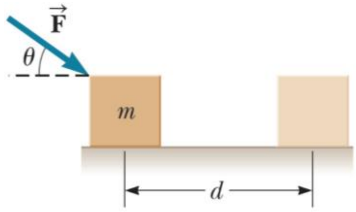
OR

$P_1 = \vec{F}_1 \cdot \vec{v} = (50)(5) + (60)(3) = 430\ W$

$P_2 = \vec{F}_2 \cdot \vec{v} = (120)(5) + (80)(3) = 840\ W$

$P = P_1 + P_2 = 1270\ W$

SP5. A 3 kg block is pushed a distance $d = 5\ m$ along a frictionless horizontal floor by a constant applied force of magnitude $F = 16\ N$ directed at an angle $\theta = 36.9^o$ as shown in the figure. **Determine the work done on the block by the applied force.**



$W_F = \vec{F} \cdot \vec{d} = F\ d \cos(\theta)$

$W_F = (16)(5)\cos(36.9^o) = 64\ J$

SP6. How many **revolutions per minute (rpm)** would **a 20 m diameter** Ferris wheel need to make so that the passengers feel **"weightless"** at the top-most point?

$$n - mg = -\frac{mv^2}{R}$$

feel weightless $\Rightarrow n = 0 \Rightarrow mg = \dfrac{mv^2}{R} \Rightarrow v = \sqrt{Rg} = 10\ m/s$

$$f = v\left(\frac{60}{2\pi R}\right) = 10\left(\frac{60}{2(3.14)(10)}\right) = 9.55\ rpm$$

SP7. A block of mass m is **at rest** at point (0, 0) m. A net force $\vec{F} = (4\hat{\imath} + 2\hat{\jmath})\ N$ acts on the block **for 10 s** to move it to the point (20, 10) m. **Find the mass of the block.**

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

$$(20\hat{\imath} + 10\hat{\jmath}) = 0 + 50\vec{a}$$

$$\Rightarrow \vec{a} = (0.4\hat{\imath} + 0.2\hat{\jmath})\ m/s^2$$

$$\vec{F} = m\vec{a}$$

$$4\hat{\imath} + 2\hat{\jmath} = m(0.4\hat{\imath} + 0.2\hat{\jmath})$$

$$\Rightarrow m = 10\ kg$$

OR

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

$$(20\hat{\imath} + 10\hat{\jmath}) = 0 + 50\vec{a}$$

$$\Rightarrow \vec{a} = (0.4\hat{\imath} + 0.2\hat{\jmath})\ m/s^2$$

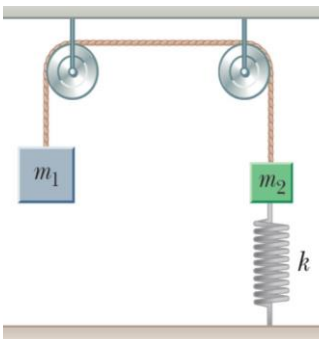
$$\vec{v} = \vec{v}_o + \vec{a}t = (4\hat{\imath} + 2\hat{\jmath})m/s \quad \Rightarrow v = \sqrt{4^2 + 2^2} = \sqrt{20}\ m/s$$

$$\vec{r} = (20\hat{\imath} + 10\hat{\jmath})\ m$$

$$Work = \vec{F}\cdot\vec{r} = \Delta K = \frac{1}{2}mv^2 - 0$$

$$(4)20 + 2(10) = \frac{1}{2}m(20) \Rightarrow m = \frac{100}{10} = 10\ kg$$

SP8. Two blocks ($m_1 = 8\ kg,\ m_2 = 2\ kg$) are connected by a light cord that passes over two frictionless pulleys as shown in the figure. The block of mass m_2 is attached to a spring of force constant $k = 500\ N/m$. If the system is **released from rest**, and the **spring is initially not stretched or compressed**, **find the maximum displacement d of m_2.**

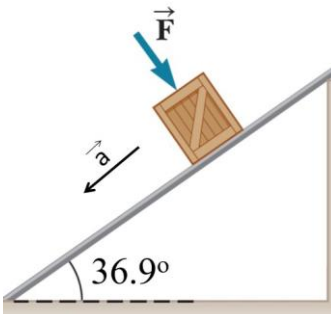


$$E_i = E_f$$

$$0 = m_2 g d + \frac{1}{2}kd^2 - m_1 g d$$

$$d = \frac{(m_1 - m_2)g}{\frac{1}{2}k} = 0.24\ m$$

SP9. The force $F = 16\ N$ is applied on a 3 kg box perpendicular to the rough incline ($\mu_k = 0.3$). **With what acceleration will the box slide down?**



$$n = F + mg\cos(36.9^o) = 16 + 30\cos(36.9^o) = 40\ N$$

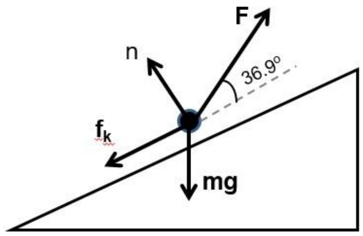
$$mg\sin(36.9^o) - \mu_k n = ma$$

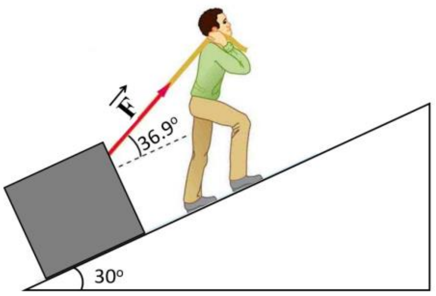
$$a = \frac{mg\sin(36.9^o) - \mu_k n}{m} = \frac{18 - 12}{3} = 2\ m/s^2$$

Part III: Long Problems (4 points each)

LP1. A man pulls a 20 kg box and the box moves with **constant speed** up **a rough** ramp as shown in the figure. The length of the ramp is 3 m and the man pulls with a force of $F = 200\ N$.

a) Draw the free body diagram for the box





b) Find the work done on the box by gravity

$W_{mg} = -mgh = -mgL\ sin(30^o) = -(20)(10)(3)(\sin(30^o)) = -300\ J$

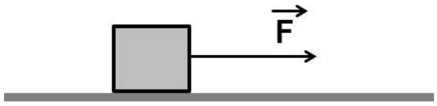
c) Find the work done on the box by the man

$W_F = |\vec{F}||\vec{d}| \cos(36.9^o) = 200(3)(0.8) = 480\ J$

d) Find the work done on the box by the normal force n.

$W_n = 0$

LP2. A constant horizontal force F is applied on the 20 kg box and the box moves **with constant speed** on a rough horizontal surface ($\mu_k = 0.5$) as shown in the figure.



a) Find the magnitude of the friction force.

$f_k = \mu_k mg = (0.5)(200) = 100\ N$

b) Find the magnitude of the applied force.

$F = f_k = 100\ N$

c) Find the total work done on the box.

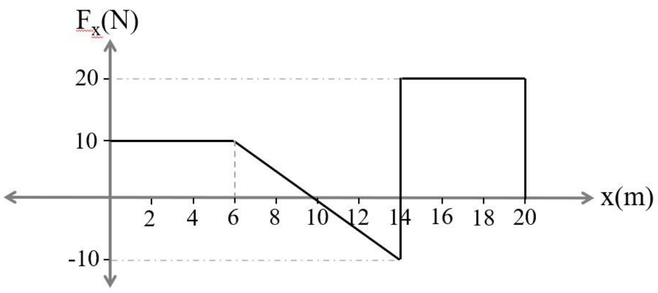
Since $\vec{v}$ *is constant* $\Rightarrow$ $W_{total} = 0$

d) With what acceleration will the box move after removing the applied force F?

$f_k = ma = 20\ a$

$-100\ N = 20\ a \Rightarrow a = -5\ m/s^2$

LP3. An object of mass 4.8 kg rests on a frictionless horizontal surface. A variable force is applied on the object to move it from the origin along the x-axis. The force as a function of position is shown in the graph.



a) What is the speed of the object at x = 6 m.

$$W = \frac{1}{2}m\left(v_f^2 - v_i^2\right) = Area$$

$$60\,J = 2.4\left(v_f^2 - 0\right) \Rightarrow v(6\,m) = 5\,m/s$$

b) What is the work done on the object by the force F_x as it moves from $x = 0\ m$ to $x = 20\ m$?

$$W = Area = 6(10) + 6(20) = 180\,J$$

c) At what position, if any, does the acceleration change from positive to negative.

$At \quad x = 10\,m$

d) At what position, if any, does the direction of the velocity change from positive to negative.

None