Kuwait University Physics Department

Physics 101

Fall Semester

Second Midterm Exam

Saturday, December 10, 2022

8:00 AM – 9:30 AM

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

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

Choose your Instructor's Name:

Dr. Hala Al- Jassar	Dr. Abdul Khaleq
Dr. Tareq Alrefai	Dr. Nasser Demir
Dr. Fatema Al Dosari	Dr. Ruqayyah Askar
Dr. Belal Salameh	Dr. Bedoor Alkurtass

For Instructors Use Only

Grades:

#	SP1	SP2	SP3	SP4	SP5	LP1	LP2	Q1	Q2	Q3	Q4	Total
Pts	2	2	2	2	2	3	3	1	1	1	1	20

Important:

1. Answer all questions and problems (No solution = no points).
2. Full mark = 20 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 and smart watches are **strictly prohibited** 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. Three forces $\vec{F}_1 = (50\hat{\imath} - 60\hat{\jmath})\ N,\ \vec{F}_2 = (-70\hat{\imath} + 20\hat{\jmath})\ N, and\ \vec{F}_3$ act on a 4 kg block. If the acceleration of the block is $\vec{a} = (6\hat{\imath} - 2\hat{\jmath})\ m/s^2$, **find $\vec{F}_3$ in unit vector notation.**

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

$$\vec{F}_1 + \vec{F}_2 + \vec{F}_3 = m\vec{a} \Rightarrow \vec{F}_3 = m\vec{a} - \vec{F}_2 - \vec{F}_3$$

$$\vec{F}_3 = 4(6\hat{\imath} - 2\hat{\jmath}) - (50\hat{\imath} - 60\hat{\jmath}) - (-70\hat{\imath} + 20\hat{\jmath}) = (44\hat{\imath} + 32\hat{\jmath})\ N$$

SP2. The mass of an elevator together with its passengers is 500 kg. At a certain instant, the tension in the supporting cable of the elevator is 6000 N. **Determine the magnitude of its acceleration at this moment.**

Since $T > mg \Rightarrow a$ is upward

$$T - mg = ma$$

$$\Rightarrow a = \frac{T - mg}{m} = \frac{6000 - 5000}{500} = 2\ m/s^2$$

SP3. A 10 kg rock starts sliding on **a rough horizontal surface** at 8 m/s and **stops** after 2 s due to **a constant** **frictional force**. **What average power is produced by friction during the 2 s slide?**

$$w_{net} = \Delta K = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = -320\ J$$

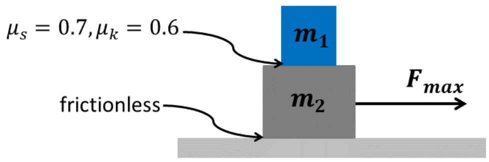
$$P_{av} = \frac{w_{net}}{t} = \frac{-320}{2} = -160\ w$$

OR

$$F_{friction} = ma = m\frac{\Delta v}{\Delta t} = 10\left(\frac{8}{2}\right) = 40\ N$$

$$P_{av} = \vec{F} \cdot \vec{v}_{av} = -40\left(\frac{8}{2}\right) = -160\ w$$

SP4.Two blocks ($m_1 = 5\ kg, m_2 = 12\ kg$) are placed on top of each other. Initially, the blocks are at rest, then m_2 is pulled with a horizontal force F and the system starts moving. **Find the maximum value of the force (F_{max}) such that m_1 <u>does not slide</u> on m_2.**



for block 1

$$f_{s_{max}} = \mu_s m_1 g = m_1 a \Rightarrow a = \mu_s g = 7\ m/s^2$$

for the two blocks

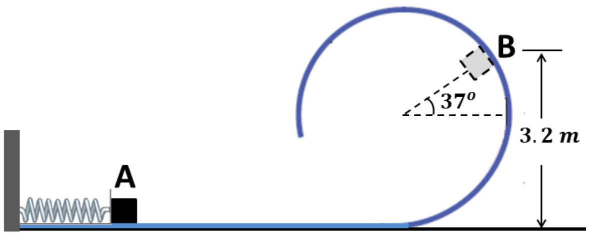
$$F_{max} = (m_1 + m_2)\ a = 119\ N$$

<u>OR</u>

(for block 2)

$$F_{max} - f_{s_{max}} = m_2\ a \Rightarrow F_{max} = \mu_s m_1 g + m_2\ a = 0.7(5)(10) + 12(7) = 119\ N$$

SP5. A 0.5 kg box compresses a spring 20 cm at point A, then it is released from rest, as shown. The box slides on **a frictionless surface** and reaches a circular track of radius $R = 2\ m$, **the box leaves the track at point B**. **Find the spring constant (in N/m).**



At point B, $n = 0$

$$\Rightarrow mg\sin(37^o) = m\frac{v_B^2}{R}$$

$$\Rightarrow v_B = \sqrt{gR\sin(37^o)} = 3.47\ m/s$$

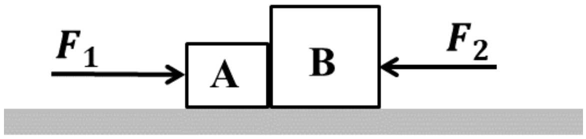
$$\frac{1}{2}kx_A^2 = \frac{1}{2}mv_B^2 + mgy_B \Rightarrow k = \frac{m}{x_i^2}(v_B^2 + 2gy_B)$$

$$= \frac{0.5}{0.2^2}\left(3.47^2 + 2(10)(3.2)\right) = 950\ N/m$$

Part II: Long Problems (3 points each)

LP1. Two blocks ($m_A = 8\ kg\ and\ m_B = 16\ kg$) on **a frictionless horizontal** surface are in contact with each other. **Two horizontal** forces ($F_1 = 360\ N,$ and $F_2 = 216\ N$) are applied to the blocks, as shown.

a) Find the magnitude of the acceleration of the system.



$$\sum F = m_{total} a$$

$$360 - 216 = 24\ a \Rightarrow a = 6\ m/s^2$$

b) Find the magnitude of the net force on block B.

$$\sum F_{on\ B} = m_B a = 16(6) = 96\ N$$

c) Find the magnitude of the contact force between the two blocks.

$$\sum F_{on\ B} = m_B a = F_{AB} - F_2$$

$$F_{AB} = m_B a + F_2 = 96 + 216 = 312\ N$$

OR

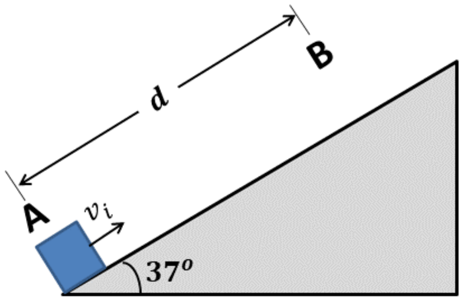
$$\sum F_{on\ A} = m_A a = F_1 - F_{BA}$$

$$F_{BA} = F_2 - m_A a = 360 - 8(6) = 312\ N$$

LP2. A 20 kg block starts moving up **a rough incline** at point A with initial speed $v_i = 2\ m/s$. **It <u>stops</u> momentarily at point B**. The coefficient of kinetic friction between the block and the incline is $\mu_k = 0.5$.

a) Find the total work done on the block as it moves from A to B.

$$w_{total} = \Delta K = \frac{1}{2}m\left(v_f^2 - v_i^2\right) = \frac{1}{2}(20)(0^2 - 2^2) = -40\ J$$



b) Find the distance d.

$$\Delta K = w_{total} = w_{f_k} + w_{mg}$$

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

$$-40 = -\mu_k mg\cos 37^o \mathrm{d} - mgd\sin 37^o$$

$$d = \frac{40}{mg(\mu_k\cos 37^o + \sin 37^o)} = 0.2\ m$$

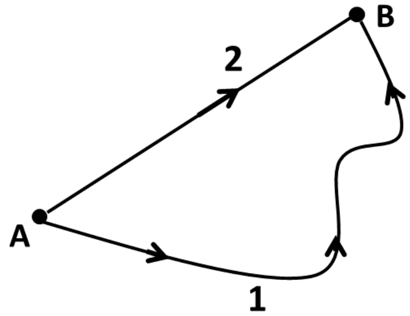
c) Find the change in the gravitational potential energy of the block as it moves from A to B.

$$\Delta U_g = mgy_f - mgy_i = mgd\sin 37^o - 0 = (20)(10)(0.2)\sin 37^o = 24\ J$$

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

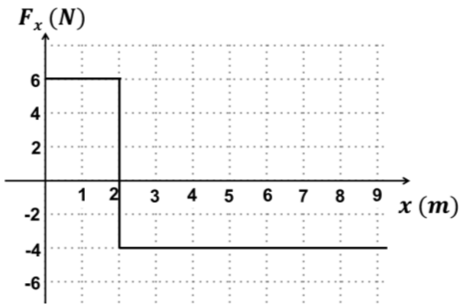
Q1. A **conservative force** is applied to a particle as it moves from point A to point B. If W_1 and W_2 represent the work done by this force along the paths 1 and 2, respectively then

* $W_1 = W_2$
* $W_1 = -W_2$
* $W_1 > W_2$
* $W_1 < W_2$



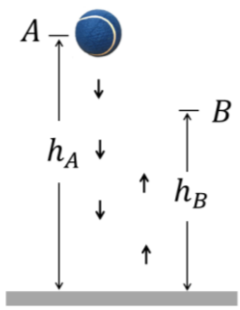
Q2. The net force exerted on a particle that is moving along the x-axis is shown. The particle starts at $x = 0\ m$ with a speed **of 2 m/s along the positive x-axis. The speed of the particle will be 2 m/s along the negative x-axis at:**

* $x = 2\ m.$
* $x = 4\ m$
* $x = 5\ m$
* $x = 6\ m$



Q3. A ball is **released from rest** from a height h_A (point A). It strikes the floor and rebounds to a **maximum height** h_B (point B), as shown. The work done on the ball by the gravity (W_g) and the corresponding change in total mechanical energy (ΔE) between points A and B are

* $W_g > 0\ and\ \Delta E = 0$
* $W_g < 0\ and\ \Delta E = 0$
* $W_g < 0\ and\ \Delta E < 0$
* $W_g > 0\ and\ \Delta E < 0$



Q4. A block is released from rest at a height h above the ground and moves along a **frictionless** surface. If the hills have **the same heights and different radii**, as shown. The relation between the **normal force** exerted on the block at points a, b, and c is:

* $n_a > n_b > n_c$
* $n_c > n_b > n_a$
* $n_a = n_b = n_c$
* $n_b > n_c > n_a$