Kuwait University **Physics Department**

Physics 101

Summer Semester

Final Exam

Monday, July 27, 2026

12:00 PM – 2:00 PM

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

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

Choose your Instructor's Name:

Instructors: Drs. Al Dosari, Al Jassar, Al Qattan, Al Smadi, Askar, Salameh, Zaman

For Instructors use only

Grades:

#	SP1	SP2	SP3	SP4	SP5	SP6	SP7	LP1	LP2	LP3	Q	Total
Pts	3	3	3	3	3	3	3	5	5	5	4	40

Model Answer

Important:

1. Answer all questions and problems (No solution = no points).
2. Full mark = 40 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 **strictly prohibited** during the exam.
6. Programmable calculators, which can store equations, are not allowed.
7. Please box your answers.
8. **Cheating incidents will be processed according to the university rules.**

GOOD LUCK

Part I: Short Problems (3 points each)

SP1. A 0.6 kg ball initially moves with velocity $\vec{v}_i = (6\hat{\imath} + 7\hat{\jmath})\ m/s$. After being struck, its velocity becomes $\vec{v}_f = (2\hat{\imath} - 4\hat{\jmath})\ m/s$. Find the **impulse** exerted on the ball **in unit vector notation**.

$$\vec{J} = \Delta\vec{p} = m(\vec{v}_f - \vec{v}_i) = 0.6\,[(2\hat{\imath} - 4\hat{\jmath}) - (6\hat{\imath} + 7\hat{\jmath})]$$

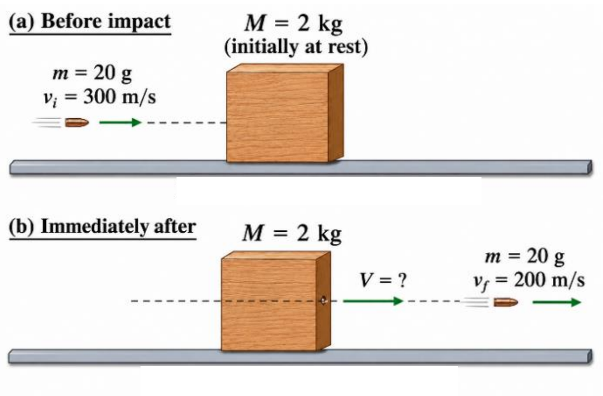
$$\vec{J} = (-2.4\hat{\imath} - 6.6\hat{\jmath})N \cdot s$$

SP2. A bullet of mass $m = 0.02\ kg$ travels **horizontally** at a speed of $300\ m/s$. It strikes a block of mass $M = 2\ kg$, initially at **rest** on a frictionless horizontal surface. The bullet passes through the block and exits with a speed of $200\ m/s$. Find the **speed** of the block **immediately after the bullet exits**.

$$mv_{1x_i} + Mv_{2x_i} = mv_{1x_f} + Mv_{2x_f}$$

$$0.02(300) + 2(0) = 0.02(200) + 2v_{2x_f}$$

$$v_{2x_f} = 1\ m/s$$



SP3. A wheel rotates through $24\ rad$ in $2\ s$ as it is **uniformly** brought to **rest**. **Find the initial angular velocity** (in rad/s) of the wheel before breaking began.

$$\frac{\Delta\theta}{\Delta t} = \frac{24}{2} = \frac{\omega_i + \omega_f}{2} = \frac{\omega_i}{2}$$

$$\omega_i = 24\ rad/s$$

OR:

$\omega_f = \omega_i + \alpha t$, so $\alpha = \frac{0-\omega_i}{2} = -\frac{\omega_i}{2}$

$$\Delta\theta = \omega_i t + \frac{1}{2}\alpha t^2 = 2\omega_i - \frac{1}{4}\omega_i(4) = \omega_i$$

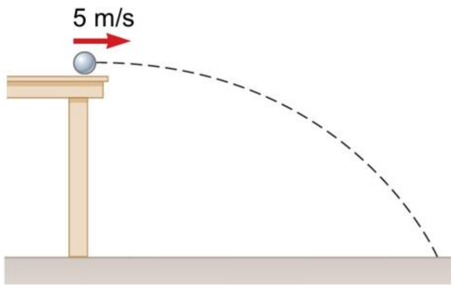
$$\omega_i = 24\ rad/s$$

SP4. A ball is **projected <u>horizontally</u>** from the edge of a table with a speed of 5 m/s and reaches the ground after $t = 1.2\ s$, as shown. Find the **<u>speed</u>** of the ball (in m/s) **<u>just before it hits the ground</u>**.

$$v_{x_f} = v_{x_i} = 5\ m/s$$

$$v_{y_f} = v_{y_i} - gt = 0 - 10(1.2) = -12\ m/s$$

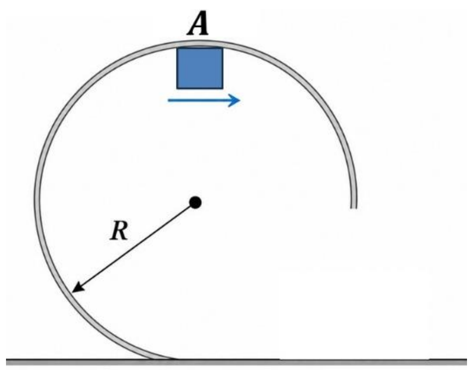
$$v_f = \sqrt{v_{x_f}^2 + v_{y_f}^2} = \sqrt{5^2 + (-12)^2} = 13\ m/s$$



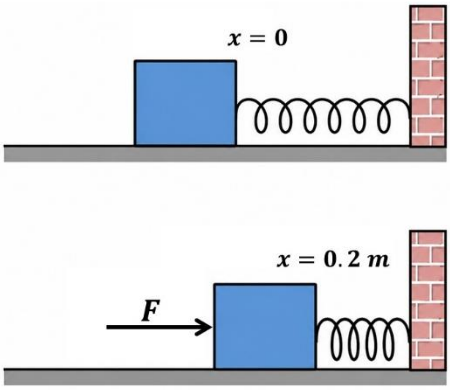
SP5. A small block ($m = 0.2\ kg$) moves inside a **frictionless** circular track of radius $R = 0.8\ m$, as shown. At the top of the track (point A), the **normal force** exerted on the block is 20 N. **Find the speed of the block at point A.**

$$n_B + mg = m\frac{v_B^2}{R}$$

$$v_B = \sqrt{\frac{(n_B + mg)R}{m}} = \sqrt{\frac{(20 + 2)(0.8)}{0.2}} = 9.4\ m/s$$



SP6. A block is attached to a spring ($k = 600\ N/m$) on a horizontal **frictionless** surface. Initially, the spring is **unstretched ($x = 0$),** and the block is **at rest**. A constant horizontal force $|\vec{F}| = 200\ N$ is applied to the block, causing the spring to compress. Find the **kinetic energy (in *J*)** of the block when the spring is compressed by $x = 0.2\ m$.



$$W_F + W_{F_s} = K_f - K_i$$

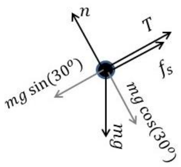
$$Fd + \frac{1}{2}k(x_i^2 - x_f^2) = K_f - 0$$

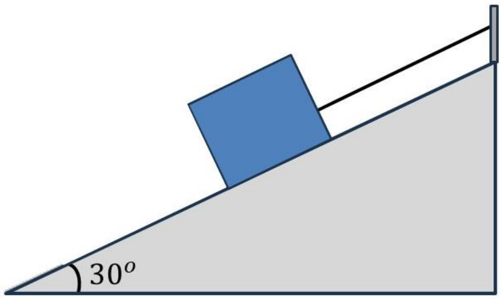
$$200\ (0.2) + \frac{1}{2}(600)(0 - 0.2^2) = K_f$$

$$K_f = 28\ J$$

SP7. A 90 kg block is **held __at rest__** on **a __rough__** inclined ramp by a light cable, as shown. If the tension in the cable is $T = 400\ N$. Find the **magnitude of the friction force** acting on the block.

$$\sum F_x = 0$$





$mg\ sin(30) = 450\ N$ down the incline

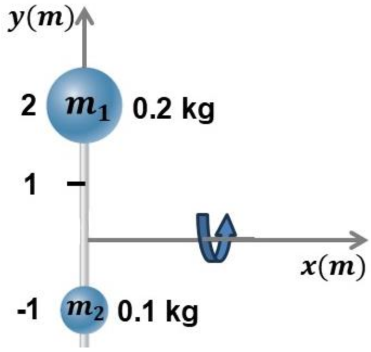
$T = 400\ N$ up the incline

So, the static frictional force is up

$\Rightarrow f_s = 450 - 400 = 50\ N$ up the incline

Part II: Long Problems (5 points each)

LP1. Two small balls are connected by a thin, massless rod aligned along the y-axis. The system rotates about the $x-axis$, as shown. The angular position is given by $\theta(t) = 10t^2 - 2t^3$, where θ is in radians and t is in seconds.



a) **Find the moment of inertia of the system about the x-axis**.

$$I = m_1 r_1^2 + m_2 r_2^2 = 0.2(2^2) + 0.1(1^2) = 0.9\ kg \cdot m^2$$

b) **Find the angular speed of the system at $t = 2s$.**

$$\omega(t) = \frac{d\theta(t)}{dt} = 20t - 6t^2$$

$$\omega(2s) = 20(2) - 6(2^2) = 16\ rad/s$$

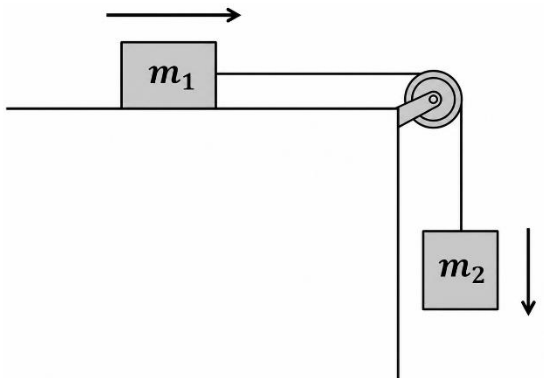
c) **Find the rotational kinetic energy of the system at $t = 2s$.**

$$K_{rot} = \frac{1}{2} I\omega^2 = \frac{1}{2}(0.9)(16^2) = 115.2\ J$$

d) **Find the linear speed (in m/s) of the $0.2\ kg$ ball at $t = 2s$.**

$$v = r\omega = 2(16) = 32\ m/s$$

LP2. Two blocks, ($m_1 = 3\ kg$ and $m_2 = 2\ kg$), are connected by a light rope passing over a frictionless, **massless** pulley, as shown. **The surface is rough**, with $\mu_k = 0.5$. The blocks are **released from rest** and move in the directions shown in the figure.



a) Find the acceleration of the two blocks.

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

$$a = \frac{m_2 g - \mu_k m_1 g}{(m_1 + m_2)} = \frac{20 - (0.5)(30)}{5} = 1\ m/s^2$$

b) Find the tension in the rope.

$$m_2 g - T = m_2 a \Rightarrow T = m_2(g - a) = 2(9) = 18\ N$$

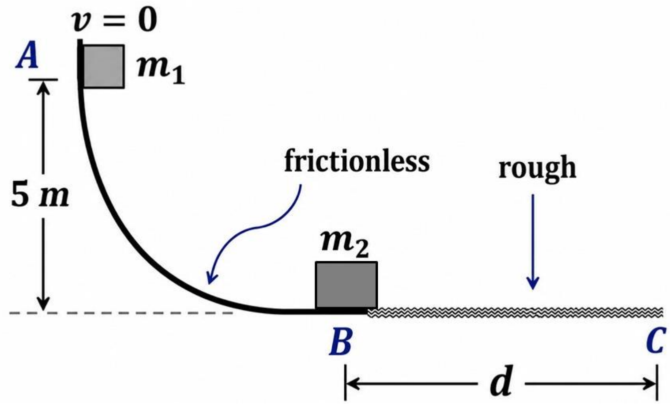
c) Find the speed of m_2 after it has moved 3 m.

$$v_{y_f}^2 = v_{y_i}^2 + 2a_y \Delta y$$

$$= 0 + 2(1)(3) = 6$$

$$v_{y_f} = \sqrt{6} = 2.45\ m/s$$

LP3. Block 1 ($m_1 = 8\ kg$) is **released from rest** at a height of 5 m, as shown. It collides with block 2 ($m_2 = 12\ kg$), which is initially at **rest**. The two blocks, made of the same material, **stick together** after the collision. The combined blocks then slide a distance ($d = 2\ m$) along a **rough** horizontal surface before coming to **rest at point C**.



a) **Find the speed of block m_1 immediately before the collision (at point B) using the conservation of energy.**

$$E_i = E_f$$

$$m_1 g y = \frac{1}{2} m_1 v^2$$

$$v = \sqrt{2gy} = \sqrt{2(10)(5)} = 10\ m/s$$

b) **Find the speed of the combined blocks immediately after the collision.**

$$m_1 v_{1_i} = (m_1 + m_2) v_f$$

$$v_f = \frac{m_1}{(m_1 + m_2)} v_{1_i} = \frac{8}{20}(10) = 4 m/s$$

c) **Find the coefficient of kinetic friction (μ_k) between the blocks and the horizontal rough surface.**

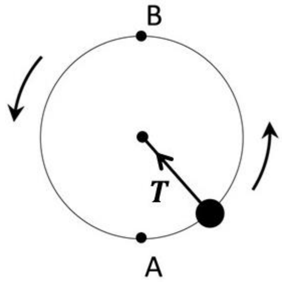
$$E_f - E_i = W_{f_k}$$

$$0 - \frac{1}{2}(m_1 + m_2) v^2 = -\mu_k (m_1 + m_2) g d$$

$$\mu_k = \frac{v^2}{2gd} = \frac{4^2}{2(10)(2)} = 0.4$$

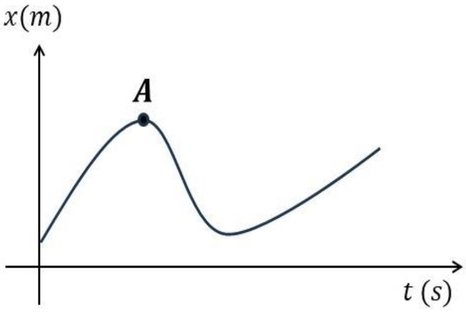
Part III: Questions (Choose the correct answer, one point each)

Q1. An object of mass m is attached to a string and moves along **a vertical circular path** of radius R, as shown. **The work done by the tension force (T)** as the object moves from point A to point B is:



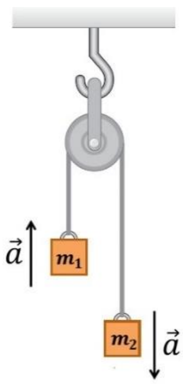
* πRT
* $\pi R\,mg$
* $2R\,mg$
* zero

Q2. The graph shows the position of a particle moving along the $x-axis$ as a function of time. Which of the following statements is **correct** for the particle at point A?



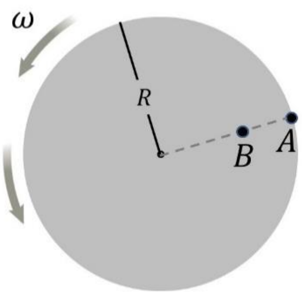
* $v_x = 0$ and $a_x = 0$
* $v_x = 0$ and $a_x < 0$
* $v_x = 0$ and $a_x > 0$
* $v_x > 0$ and $a_x = 0$

Q3. Two blocks are connected by a light rope passing over a **massless** pulley, as shown. Block $\boldsymbol{m_1}$ **accelerates <u>upward</u>**. Which of the following statements about the tension (T) in the rope is **correct**?



* $m_1 g > T > m_2 g$
* $m_2 g > T > m_1 g$
* $m_1 g = T = m_2 g$

Q4. A solid disc rotates about its centre with angular velocity ω. Points A and B are located at different distances from the centre, as shown. **Which one of the following statements is correct?**



* $\omega_A = \omega_B$
* $v_A = v_B$
* $\omega_A > \omega_B$
* $v_A < v_B$