Kuwait University Physics Department

Physics 101

Summer Semester

Final Exam

Monday, August 4, 2025

12:00 – 14:00

Student's Name: ……. Serial Number: ……

Student's Number: ……Section: ……

Choose your Instructor's Name:

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

For Instructors use only

Grades:

#	SP1	SP2	SP3	SP4	SP5	SP6	SP7	LP1	LP2	LP3	Q1	Q2	Q3	Q4	Total
Pts	3	3	3	3	3	3	3	5	5	5	1	1	1	1	40

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. **Cheating incidents will be processed according to the university rules.**

GOOD LUCK

Part I: Short Problems (3 points each)

SP1. A particle moves along the x-axis. Its position is given by $x(t) = t^2 - 6t + 8$, where x is in m and t is in s. **Find the average velocity of the particle during the interval from $t = 1\ s$ to $t = 4\ s$.**

$x_i = x(t = 1\ s) = 1^2 - 6(1) + 8 = 3\ m$

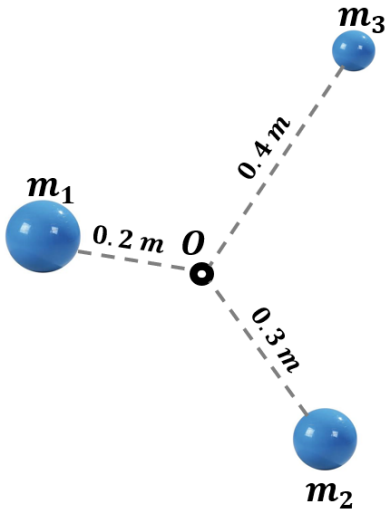
$x_f = x(t = 4\ s) = 4^2 - 6(4) + 8 = 0\ m$

$$v_{av-x} = \frac{x_f - x_i}{\Delta t} = \frac{0 - 3}{3} = -1\ m/s$$

SP2. Three small masses $m_1 = 0.3\ kg$, $m_2 = 0.2\ kg$, and $m_3 = 0.1\ kg$ are rotating about **a vertical axis passing through point O** with an angular speed of $\omega = 40\ rad/s$, as shown. **Find the rotational kinetic energy of the system**.

$$I = \Sigma\, m_i r_i^2 = m_1\,(0.2)^2 + m_2\,(0.3)^2 + m_3\,(0.4)^2$$
$$= 0.046\ kg \cdot m^2$$

$$K_{rot} = \frac{1}{2} I\omega^2 = \frac{1}{2}(0.046)(40^2) = 36.8\ J$$

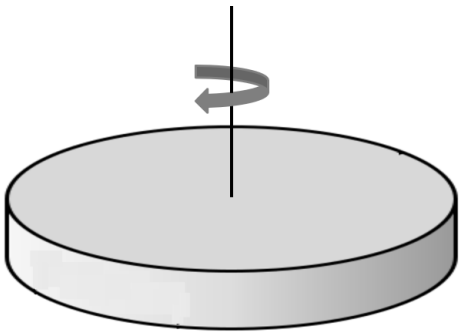


SP3. A solid disk begins rotating with an angular speed of 12 rad/s. It slows down **uniformly** until it stops in 60 s. **How many revolutions does the disk complete during this time?**

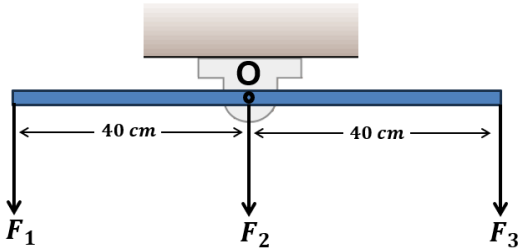
$$\alpha = \frac{\omega_f - \omega_i}{t} = \frac{0 - 12}{60} = -0.2\ rad/s^2$$

$$\Delta\theta = \omega_i t + \frac{1}{2}\alpha t^2 = 12(60) + \frac{1}{2}(-0.2)(60^2) = 360\ rad$$

$$number\ of\ revolutions = \frac{360}{2(3.14)}\ rev = 57.3\ rev$$



SP4. A uniform, massless rod of length $l = 80\ cm$ is attached to a frictionless pivot at point O and is free to rotate about this point. Three forces $F_1 = 200\ N$, $F_2 = 400\ N$, and $F_3 = 300\ N$ are applied, as shown. As the system starts rotating, **find the magnitude and direction of the initial net torque acting on the rod about the pivot point.**



$$\sum \tau = +F_1(0.4) + F_2(0) - F_3(0.4)$$

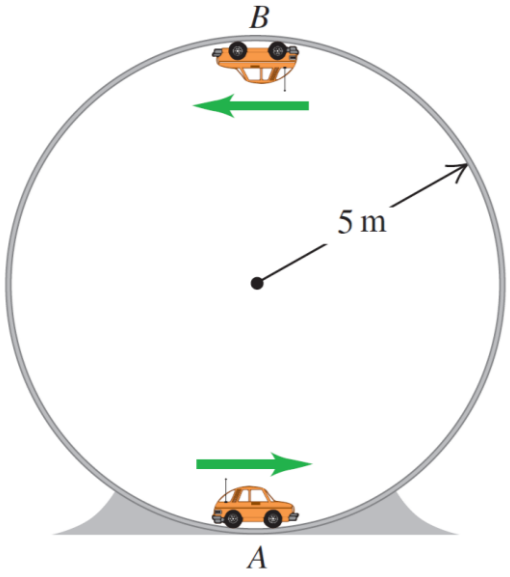
$$\sum \tau = -40\ N.m\ (clockwize)$$

SP5. A 2 kg toy car travels at **constant speed** on the inside of a track that is a **vertical circle** with a radius of $R = 5\ m$, as shown. If the normal force exerted on the car at **point B** is $n = 5.6\ N$, **how much time does it take the car to complete one revolution around the track?**

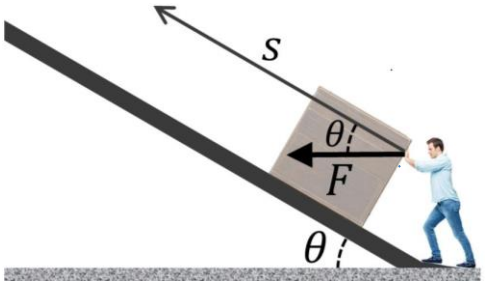
$$n_B + mg = m\frac{v^2}{R}$$

$$v = \sqrt{\frac{R}{m}(n_B + mg)} = \sqrt{\frac{5}{2}(5.6 + 20)} = 8\ m/s$$

$$v = \frac{2\pi R}{T} \quad \Rightarrow \quad T = \frac{2\pi R}{v} = \frac{2(3.14)(5)}{8} = 3.9\ s$$



SP6. A man pushes a box up a **frictionless** incline ($\theta = 40°$) with a constant **horizontal force** of $F = 50\ N$, as shown. If the box moves a distance $s = 3\ m$ at **constant speed**, find the **work done by gravity** on the box.



$$\sum W = W_{mg} + W_F = \Delta K = 0$$

$$W_{mg} = -W_F = -F(s)\ cos\theta$$

$$W_{mg} = -50(3)cos40° = -115\ J$$

OR

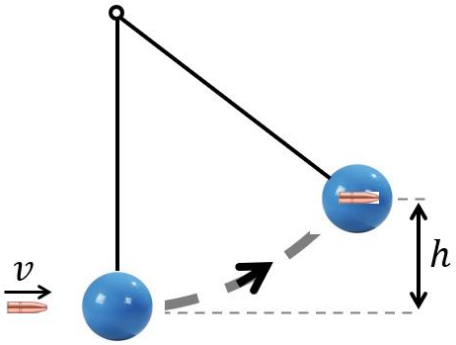
$$\sum \vec{F} = 0$$

$$Fcos\theta - mgsin\theta = 0$$

$$m = \frac{Fcos\theta}{gsin\theta} = \frac{50cos40}{10sin40} = 5.96\ kg$$

$$W_{mg} = -mgssin\theta = -59.6(3)(0.64) = -115\ J$$

SP7. A bullet of mass $m = 10\ g$ moves at a speed v and makes a **completely inelastic collision** with a stationary ball of mass $M = 0.59\ kg$, which is suspended by a light rope, as shown. After the impact, the ball swings in a vertical circle to a **maximum height** of $h = 20\ cm$. Find the **bullet's speed v before the impact**.



$$\frac{1}{2}(m+M)v_a^2 = (m+M)gh$$

$$mv = (m+M)v_a$$

$$v = \frac{(m+M)}{m}\sqrt{2gh} = 120\ m/s$$

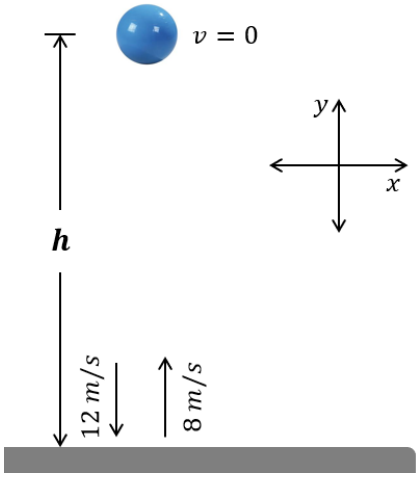
Part II: Long Problems (5 points each)

LP1. A 0.5 kg ball is released **from rest** from a height h above the ground. It strikes the ground with a speed of 12 m/s and rebounds vertically upward with a speed of 8 m/s, as shown. Ignore air resistance.

a) Find the height *h* from which the ball was released.

$$v_{y_f}^2 = v_{y_i}^2 - 2g\Delta y$$

$$12^2 = 0^2 - 2(10)(-h) \Rightarrow h = 7.2\ m$$



b) Calculate the impulse ($\vec{J}$) exerted by the ground on the ball during the impact, in unit vector notation.

$$\vec{J} = \Delta\vec{p} = m(\vec{v}_f - \vec{v}_i) = 0.5(+8\hat{j} - (-12\hat{j})) = 10\,\hat{j}\ kg \cdot m/s$$

c) If the ball was in contact with the ground for 0.01 s, **find the average net force exerted on the ball by the ground in unit vector notation**.

$$\left(\sum \vec{F}\right)_{av} = \frac{\vec{J}}{\Delta t} = \frac{10\,\hat{j}}{0.01} = 1000\,\hat{j}\ N$$

LP2. A small block of mass $m = 0.4\,Kg$ starts moving **at point A with a speed of 3 m/s**. Its path is frictionless except the region between points B and C, as shown. At the end of the path **a relaxed** spring of force constant $k = 500\ N/m$ is attached to a wall.

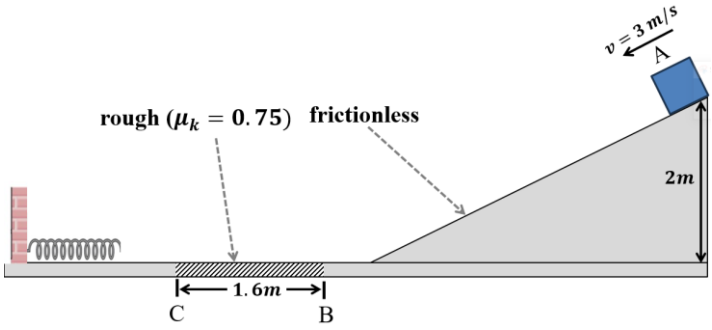
a) Find the speed of the block at point B.

$$E_A = E_B$$

$$\frac{1}{2}mv_A^2 + mgy_A = \frac{1}{2}mv_B^2$$

$$v_B = \sqrt{v_A^2 + 2gy_A} = \sqrt{3^2 + 2(10)(2)}$$

$$= 7\ m/s$$



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

$$E_C - E_B = W_{f_K}$$

$$\frac{1}{2}mv_C^2 - \frac{1}{2}mv_B^2 = -\mu_k mgd$$

$$v_C = \sqrt{v_B^2 - 2\mu_k gd} = \sqrt{7^2 - 2(0.75)(10)(1.6)} = 5\ m/s$$

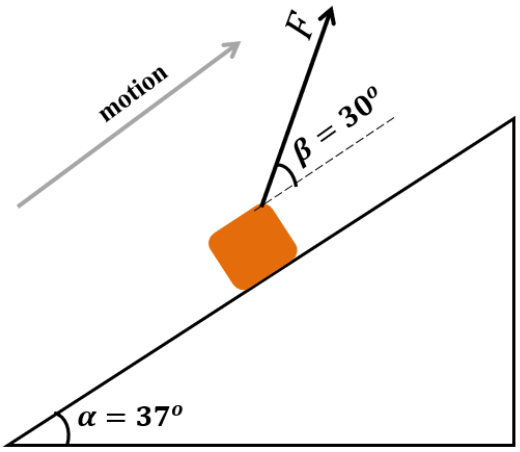
c) Find the maximum compression of the spring.

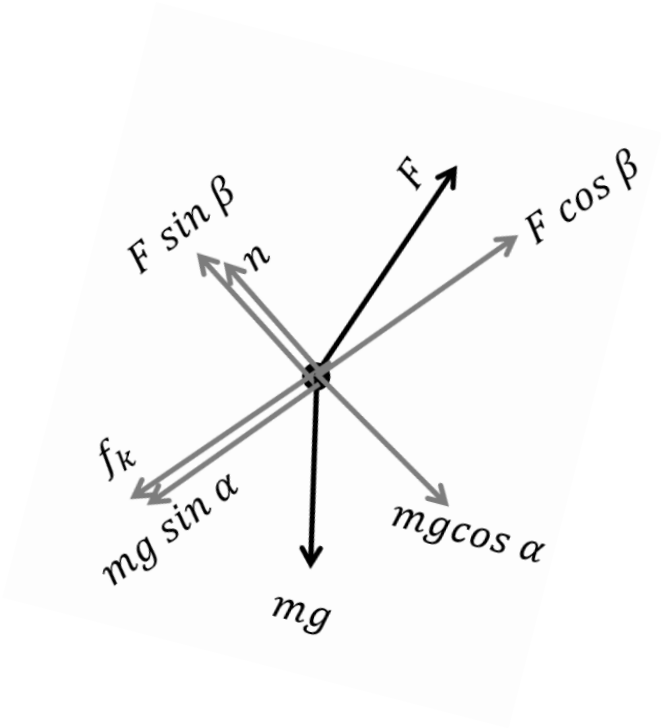
$$\frac{1}{2}mv_C^2 = \frac{1}{2}kx_{max}^2$$

$$x_{max} = \sqrt{\frac{m}{k}}v_c = \sqrt{\frac{0.4}{500}}(5) = 0.14\ m$$

LP3. A 20 kg block slides up a rough inclined plane ($\mu_k = 0.5$) under the action of a constant force of magnitude $F = 220N$, as shown.

a) Draw the free body diagram of the block.





b) Find the magnitude of the friction force acting on the block.

$n = mg\,cos\alpha - F\,sin\beta = 20(10)\cos 37^o - 220\sin 30^o = 50\ N$

$f_k = \mu_k n = 25\ N$

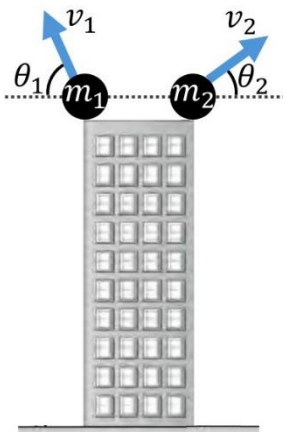
c) Find the acceleration of the block.

$F\,cos\beta - mg\sin\alpha - f_k = ma$

$220\,cos30 - 200\sin 37 - 25 = 20a \Rightarrow a = 2.26\ m/s^2$

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

Q1. Two balls with masses m_1 and m_2 are projected from the **same height** at the top of a building, as shown. If both balls **reach the ground with the same speed**, **which of the following is true about their initial projection speeds?** (Ignore air resistance)



(*) $v_1 = v_2$

* $v_1 > v_2$

* $v_1 < v_2$

* Cannot tell with the given information

Q2. A small car collides head-on with a large truck. **Which of the following statements correctly describes the magnitude of the average force exerted during the collision?**

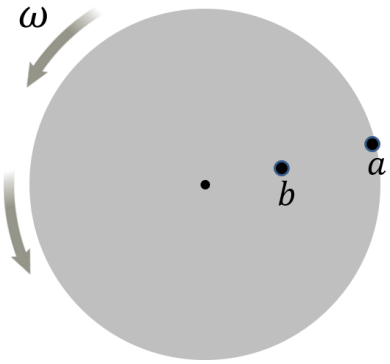
* The truck experiences a greater average force.

* The small car experiences a greater average force.

(*) The small car and the truck experience equal average forces.

* It is impossible to determine without knowing the masses.

Q3. A solid disk rotates about its center with an angular speed ω. Two points (a and b) are marked on its surface as shown. **Which of the following statements is correct?**



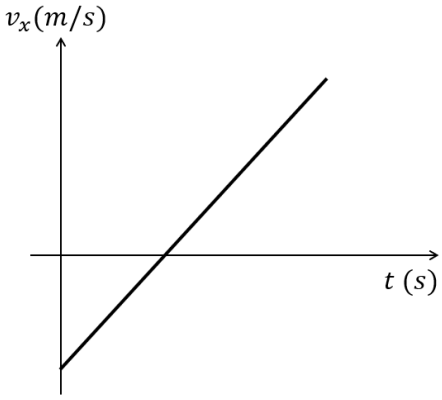
* $\omega_a = \omega_b$ and $v_a < v_b$

(*) $\omega_a = \omega_b$ and $v_a > v_b$

* $\omega_a < \omega_b$ and $v_a = v_b$

* $\omega_a > \omega_b$ and $v_a = v_b$

Q4. The velocity versus time for a particle moving along the x-axis is shown in the figure. **Which of the following statements is correct about its speed?**



* It always increases.

* It always decreases.

* It increases and then decreases.

(*) It decreases and then increases.