Kuwait University **Physics Department**

جامعة الكويت
KUWAIT UNIVERSITY

Physics 101

Spring Semester
Final Exam
Sunday, May 19, 2024
05:00 PM – 7:00 PM

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

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

Choose your Instructor's Name:

Instructors: Drs. Al Dosari, Al Jassar, Al kurtas, Al Qattan, Al Refai, Al Smadi, Askar, Demir, Salameh

Model Answer

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)

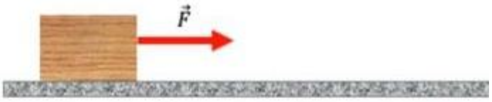
SP1. The position of a particle moving along the *x-axis* is given by $x(t) = (21 + 22t - 6t^2)$, where x is in m and t is in s. **What is the average velocity during the time interval, $t = 1$ s to $t = 3$ s?**

$$v_{av-x} = \frac{\Delta x}{\Delta t} = \frac{x(3) - x(1)}{3 - 1}$$

$$v_{av-x} = \frac{[21 + 22(3) - 6(3^2)] - [21 + 22(1) - 6(1^2)]}{2}$$

$$= -2\ m/s$$

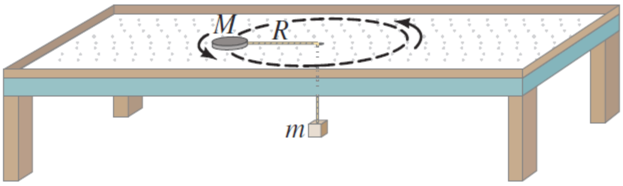
SP2. A force $\vec{F}$ is applied on a block of mass $m = 2\ kg$ that is resting on a **rough** horizontal surface ($\mu_s = 0.4$), as shown. **Find the minimum value of $|\vec{F}|$ which is required to just make the block slide**.



$$F - f_{s,max} = 0$$

$$F = f_{s,max} = \mu_s mg = 0.4 \times 20 = 8\ N$$

SP3. A small disk of mass $M = 0.3\ kg$ is rotating in a circle of radius $R = 0.6\ m$ on a **frictionless horizontal** table with a constant speed of $v = 6\ m/s$. The disk is connected by a light string to a suspended block of mass m through a central hole, as shown. **The block m remains at rest. Find the mass of the suspended block (m)**.

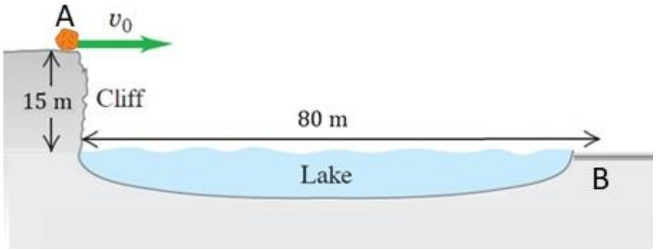


$$T = mg$$

$$T = \frac{Mv^2}{R}$$

$$m = \frac{Mv^2}{Rg} = \frac{0.3 \times 6^2}{0.6 \times 10} = 1.8\ kg$$

SP4. A rock is projected **horizontally** from the top of a vertical cliff (point A) that is 15 m above the surface of a lake, as shown. **Find the speed (v_0) of the rock at point A** so that it touches the ground at point B.



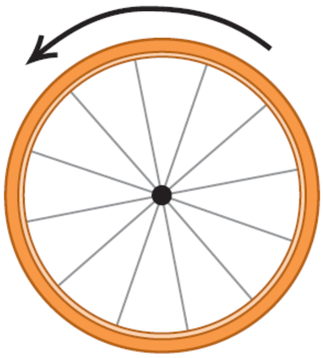
$$\Delta y = v_{y_i}t - \frac{1}{2}gt^2$$

$$-15 = 0 - 5t^2$$

$$t = 1.7\ s$$

$$v_o = v_{x_i} = \frac{\Delta x}{t} = \frac{80}{1.7} = 46.2\ m/s$$

SP5. A wheel rotates through 6 rad in 2 s as it is being brought to **rest** with **constant** angular acceleration. **Find the wheel's initial angular speed (ω_i).**



$$\omega_{av} = \frac{\omega_i + \omega_f}{\Delta t}$$

$$\frac{6}{2} = \frac{\omega_i + 0}{2}$$

$$\omega_i = 6\ rad/s$$

OR

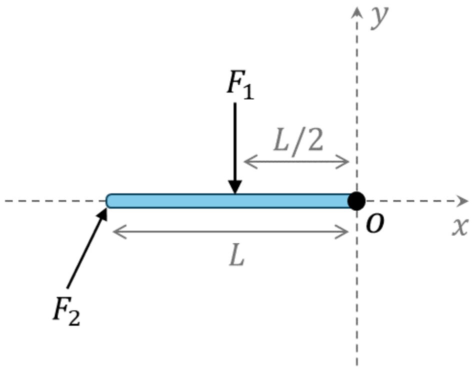
$$\omega_f = \omega_i + \alpha t$$

$$0 = \omega_i + \alpha(2) \Rightarrow \alpha = \frac{-\omega_i}{2}$$

$$\Delta\theta = \omega_i t + \frac{1}{2}\alpha t^2$$

$$6 = \omega_i(2) + \frac{1}{2}\left(\frac{-\omega_i}{2}\right)(2^2) \Rightarrow \omega_i = 6\ rad/s$$

SP6. Two forces, $\vec{F}_1 = -2\hat{j}$ N and $\vec{F}_2 = (3\hat{\imath} + 6\hat{j})$ N, are applied on a **massless rod** with a length of $L = 1.2\ m$, as shown. **Calculate the net torque vector in unit vector notation about point O due to these forces.**



$$\vec{\tau} = -6 \times 1.2 + 2 \times 0.6 = -6\ \hat{k}\ N.m$$

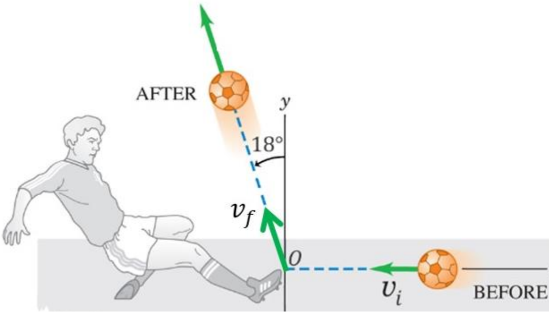
OR

$$\vec{\tau}_1 = \vec{r}_1 \times \vec{F}_1 = -0.6\ \hat{\imath} \times -2\hat{j} = +1.2\ \hat{k}\ N.m$$

$$\vec{\tau}_2 = \vec{r}_2 \times \vec{F}_2 = -1.2\ \hat{\imath} \times (3\hat{\imath} + 6\hat{j}) = -7.2\ \hat{k}\ N.m$$

$$\vec{\tau} = \vec{\tau}_1 + \vec{\tau}_2 = -6\ \hat{k}\ N.m$$

SP7. A football has a mass of 0.5 kg. Initially it is moving to the left at v_i, but then it is kicked with an average force $\vec{F}_{\text{av}} = (360\ \hat{\imath} + 1190\ \hat{j})$ N during a time of 0.01 s. Immediately after the kick, it moves at 18° upward and to the left with speed v_f, as shown. **Use the impulse-momentum theorem to find the initial speed (v_i) and the final speed (v_f) of the ball.**



$$\vec{J} = \Delta\vec{P} = \vec{P}_f - \vec{P}_i$$

$$\vec{F}\Delta t = m(\vec{v}_f - \vec{v}_i)$$

$$(3.6\hat{\imath} + 11.9\hat{j}) = 0.5\big(-v_f\ sin18^o\ \hat{\imath} + v_f\ cos18^o\ \hat{j}\big) - 0.5(-\vec{v}_i\hat{\imath})$$

$$3.6 = -0.1545 v_f + 0.5 v_i$$

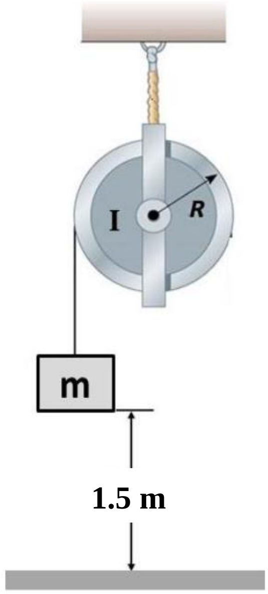
$$11.9 = 0.4755\ v_f$$

$$v_f = 25\ m/s$$

$$v_i = 14.9\ m/\text{s}$$

Part II: Long Problems (5 points each)

LP1. A block ($m = 3\ kg$) is suspended from the free end of a light rope which is wrapped around a frictionless pulley ($M = 2\ kg$, $R = 0.2\ m$, $I = 0.04\ kgm^2$), as shown. The block is released from **rest** at a distance of 1.5 m above the floor.



a) Find the block's speed just before it strikes the floor.

$$E_i = E_f$$

$$mgh = \frac{1}{2}mv_f^2 + \frac{1}{2}I\omega_f^2$$

$$mgh = \frac{1}{2}mv_f^2 + \frac{1}{2}I(\frac{v_f}{R})^2$$

$$30 \times 1.5 = \frac{1}{2} \times 3 \times v_f^2 + \frac{1}{2} \times 0.04 \times (\frac{v_f}{0.2})^2$$

$$v_f = 4.74\ m/s$$

b) Find the **angular speed of the pulley** just before the block strikes the floor.

$$\omega_f = \frac{v_f}{R} = \frac{4.74}{0.2} = 23.7\ m/s$$

c) During this motion, the **total work done by the tension** on the system of the block and the pulley is:

* positive

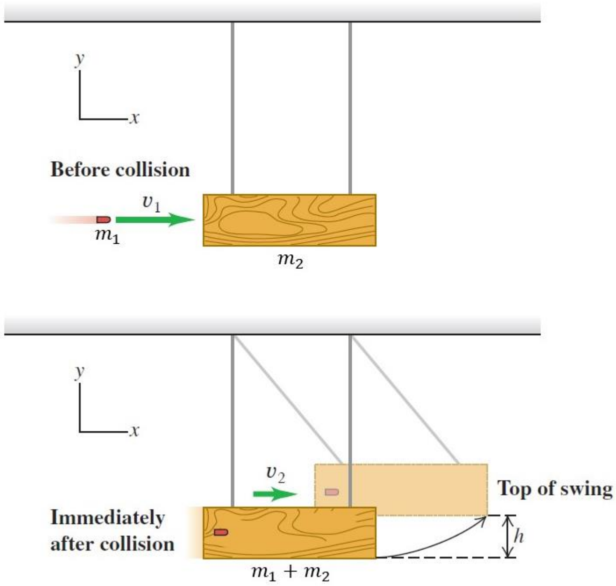
* negative

* zero

LP2. A bullet of mass of $m_1 = 50\ g$ moves horizontally with a speed of $v_1 = 250\ \mathrm{m/s}$ makes **a completely inelastic collision** with a block of wood of mass $m_2 = 4$ kg, which is suspended like a pendulum. After the impact, the system swings up to **<u>a maximum</u> height** h, as shown.

a) What is the momentum of the system **immediately after the collision?**

$$P_{xf} = P_{xi} = m_1 v_{xi} = 0.05(250) = 12.5\ kg.m/s$$



b) What is the speed of the system **immediately after the collision**?

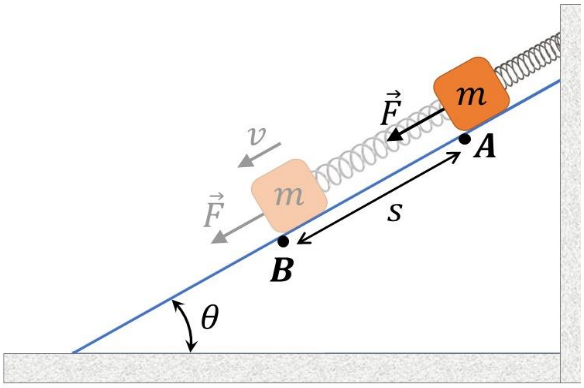
$$P_{xi} = P_{xf}$$
$$m_1 v_1 = (m_1 + m_2) v_2$$

$$v_2 = \frac{m_1 v_1}{(m_1 + m_2)} = \frac{12.5}{4.05} = 3.09\ m/s$$

c) Find the maximum height (h).

$$\frac{1}{2}(m_1 + m_2) v_2^2 = (m_1 + m_2) g h$$
$$h = \frac{v_2^2}{2g} = 0.48\ m$$

LP3. A block of mass ($m = 0.4\ kg$) is attached to a light spring ($k = 100\ N/m$) on a **rough** inclined plane ($\theta = 30°, \mu_k = 0.3$). An applied force ($|\vec{F}| = 30\ N$) acts on the block, as shown. The block is **lowered down** a distance of ($s = 0.4\ m$) from point $\boldsymbol{A}$ to point $\boldsymbol{B}$. At point **A**, the spring is relaxed ($x = 0$).



a) How much work is done on the block **by the force $\vec{F}$** from A to B?

$$W_F = \vec{F}.\vec{S} = |\vec{F}||\vec{S}|\cos(0) = 30 \times 0.4 = 12\ J$$

b) How much work is done on the block **by the force of friction** from A to B?

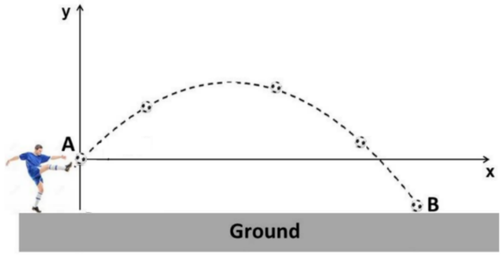
$$W_{f_k} = \vec{f_k}.\vec{S} = |\vec{f_k}||\vec{S}|\cos(180) = -\mu_k mg\cos(\theta) \times 0.4$$
$$W_{f_k} = -0.3 \times 4 \times 0.87 \times 0.4 = -0.42\ J$$

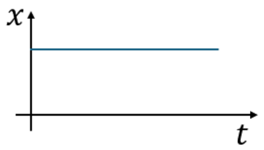
c) What is the **change in the block's kinetic energy** as it moves from A to B?

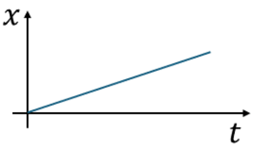
$$\Delta K = W_{tot} = W_F + W_{f_k} + W_{el} + W_g + W_n$$
$$\Delta K = 12 - 0.42 - \frac{1}{2}kx^2 + mgd\sin(\theta) + 0$$
$$\Delta K = 11.6 - 0.5 \times 100 \times (0.4)^2 + 4 \times 0.4 \times 0.5 + 0 = 4.4\ J$$

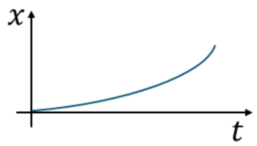
Part III: Questions (Choose the correct answer, one point each)

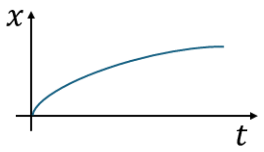
Q1. A ball is shot such that it leaves the player's foot at point A above ground level, as shown. During the ball's travel from point A to point B, **which of the following graphs represents the ball's <u>horizontal position x</u> as a function of time?** (Ignore air resistance).





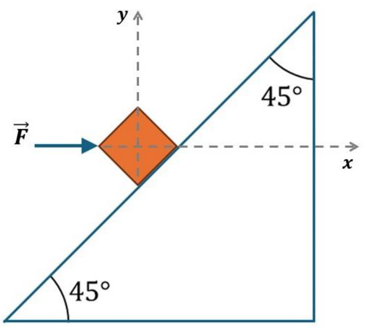






*   *   *   *

Q2. A force $\vec{F}$ is exerted horizontally on a box of mass m, as shown. The force keeps the box at rest. The incline is **frictionless. Which of the following is correct:**



- $F = mg$
- $F = mg\cos(45°)$
- $F = \frac{mg}{\cos(45°)}$
- $F = n$

Q3. A spring of force constant $\boldsymbol{k_1}$ is stretched a certain distance ($\boldsymbol{x_1}$). It requires **the same work to** stretch a second spring, with spring constant $\boldsymbol{k_2}$, by a distance ($\boldsymbol{x_2} = \frac{1}{2}\boldsymbol{x_1}$). **Which of the following is correct**:

* $k_2 = k_1$ * $k_2 = 2k_1$ * $k_2 = 4k_1$ * $k_2 = 8k_1$

Q4. In a collision between two masses ($m_1 < m_2$), which mass receives **an impulse with greater magnitude?**

* m_1 * m_2

* m_1 and m_2 receive impulses of equal magnitude.   * It depends on their initial velocities.