Kuwait University — Physics Department

جامعة الكويت
KUWAIT UNIVERSITY

Physics 101

Fall Semester

Final Exam

Monday, December 29, 2025

3:00 PM – 5:00 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, Demir, Salameh, Zaman

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 **<u>strictly prohibited</u>** 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 dog runs in a park. Its position vector (in meters) is given by $\vec{r}(t) = (8t + 0.6t^3)\,\hat{\imath} + 2t^2\,\hat{\jmath}$, where t is measured in seconds. **Find the magnitude of the dog's acceleration (in m/s^2) at $t = 2$ s.**

$$\vec{v}(t) = \frac{d\vec{r}}{dt} = [(8 + 1.8t^2)\,\hat{\imath} + 4t\,\hat{\jmath}]\ m/s$$

$$\vec{a}(t) = \frac{d\vec{v}}{dt} = (3.6t\,\hat{\imath} + 4\,\hat{\jmath})\,m/s^2$$

$$\vec{a}(2s) = (7.2\,\hat{\imath} + 4\,\hat{\jmath})\,m/s^2$$

$$|\vec{a}(2s)| = \sqrt{7.2^2 + 4^2} = 8.24\,m/s^2$$

SP2. Figure (a) shows the force–time graph for the collision of a $0.2\ kg$ ball with a vertical wall. The ball moves initially straight toward the wall at **$30\ m/s$** and **rebounds back with the same speed** in the opposite direction, as shown in Figure (b). **Find the maximum contact force F_{max} (in N) during the collision**.

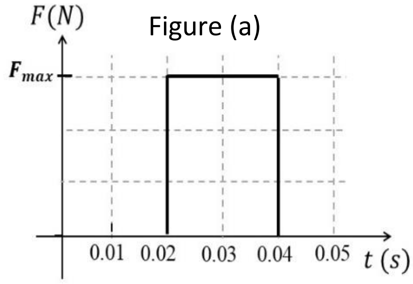


Figure (a)

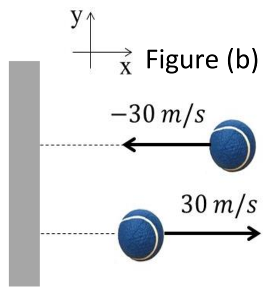


Figure (b)

$$J_x = Area = \Delta p_x$$

$$\Delta p_x = m(v_{2x} - v_{1x}) = 0.2\big(30 - (-30)\big) = 12\ kg.m/s$$

$$Area = (0.02)F_{max}$$

$$Area = (0.02)F_{max} = 12$$

$$F_{max} = 600\ N$$

SP3: A 0.5 kg object has a velocity $\vec{v} = \left(6\hat{\imath} - 4\hat{\jmath} + 3\hat{k}\right)\,m/s$ and a position vector $\vec{r} = \left(2\hat{\imath} + 4\hat{\jmath} + 2\hat{k}\right)\,m$. **Find the angular momentum ($\vec{L}$) of the object about the origin in unit vector notation**.

$$\vec{L} = \vec{r} \times \vec{p} = m\,\vec{r} \times \vec{v}$$

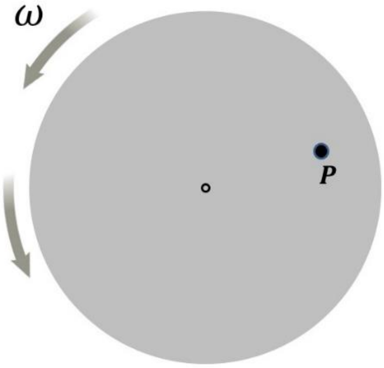
$$\vec{r} \times \vec{v} = \begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ 2 & 4 & 2 \\ 6 & -4 & 3 \end{vmatrix}$$

$$= [4(3) - 2(-4)]\hat{\imath} + [2(6) - 2(3)]\hat{\jmath} + [2(-4) - (4)(6)]\hat{k}$$

$$= (20\,\hat{\imath} + 6\,\hat{\jmath} - 32\,\hat{k})\,m^2/s$$

$$\vec{L} = m\,\vec{r} \times \vec{v} = (10\,\hat{\imath} + 3\,\hat{\jmath} - 16\,\hat{k})\ kg \cdot m^2/s$$

SP4. A disc rotates at a **<u>constant</u> angular speed** of $120\ rev/min$. **Find the radial** (a_{rad}) **and tangential** (a_{tan}) **components of the acceleration** of point **P** located at $60\ cm$ from the axis of rotation?

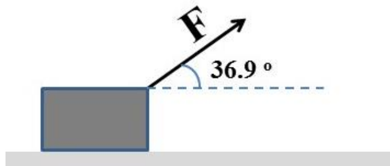


$\omega = 120\ rev/min = 12.56\ rad/s$

$a_{tan} = r\alpha = 0.6(0) = 0\ m/s^2$

$a_{rad} = r\omega^2 = (0.6)(12.56)^2 = 94.7\ m/s^2$

SP.5 A 50 kg box rests on a rough horizontal surface. The **minimum force** required to start moving the box is $|\vec{F}| = 200$ N, applied in the direction shown in the figure. **Calculate the coefficient of static friction (μ_s) between the box and the surface.**

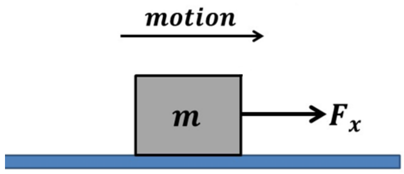


$n = mg - F\sin 36.9^0 = 380\ N$

$F\cos 36.9^0 - \mu_s n = 0$

$\mu_s = \frac{F\cos 36.9^0}{n} = 0.42$

SP6: A box moves to the right on a horizontal **frictionless** surface under the influence of a net force which varies with position according to the relation $F_x = (6x^2 - 2x)$ N, where $\boldsymbol{x}$ is in meters. **Find the total work (in $\boldsymbol{J}$) done on the box as it moves from $\boldsymbol{x = 0}$ to $\boldsymbol{x = 4}$ m.**



$$W_{F_x} = \int_{x_i}^{x_f} F_x \, dx$$

$$W_{F_x} = \int_0^4 (6x^2 - 2x)\, dx = (2x^3 - x^2)]_0^4$$

$$= +112\, J$$

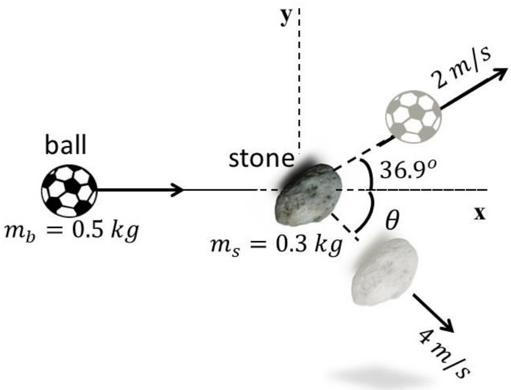
SP7. A ball $(m_b = 0.5\ kg)$ **traveling along the x-axis** collides with a stone $(m_s = 0.3\ kg)$ that **rests** on a frictionless horizontal surface. After the collision, the ball and the stone move as shown in the figure. **Find the angle $\boldsymbol{\theta}$.**

$$\sum p_{y_i} = \sum p_{y_f}$$

$$0 = m_b v_{b_f} \sin 36.9^o - m_s v_{s_f} \sin\theta$$

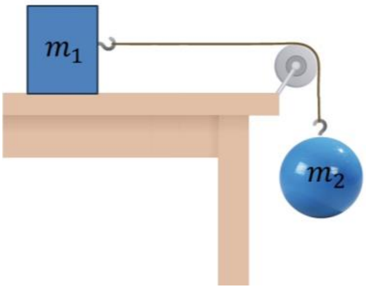
$$\theta = \sin^{-1}\left(\frac{m_b v_{b_f} \sin 36.9^o}{m_s v_{s_f}}\right)$$

$$= \sin^{-1}\left(\frac{0.5(2)\sin 36.9^o}{0.3(4)}\right) = 30^o$$



Part II: Long Problems (5 points each)

LP1. A block ($m_1 = 4$ kg) rests on a horizontal **frictionless** surface is connected to a ball ($m_2 = 6$ kg) by a massless rope that passes over a frictionless pulley ($I = 0.05\ kg \cdot m^2$, $R = 0.1\ m$), as shown.



a) If the system is released from rest, find the speed of the ball after it has fallen 0.5 m.

$$E_i = E_f$$

$$m_2 g y_i = \frac{1}{2}(m_1 + m_2)v_f^2 + \frac{1}{2} I \left(\frac{v_f}{R}\right)^2$$

$$v_f = \sqrt{\frac{2m_2 gh}{m_1 + m_2 + (\frac{I}{R^2})}} = 2 \text{ m/s}$$

b) Find the angular speed of the pulley at that instant.

$$\omega_f = \frac{v_f}{R} = 20\ rad/s$$

c) Find the total kinetic energy <u>of the system</u> at that instant.

$$E_f = E_i$$

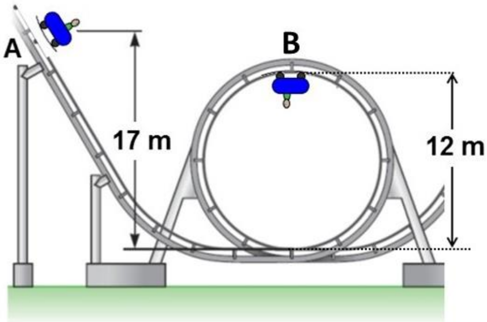
$$K_f = m_2 gh = 30\ J$$

Or

$$K_f = \frac{1}{2} m_1 v_f^2 + \frac{1}{2} m_2 v_f^2 + \frac{1}{2} I \omega_f^2 = 30\ J$$

LP2. A 150 kg roller coaster car starts from **rest at point A** and slides down the loop-the-loop shown.

a) If the speed of the car at point B is 8 m/s, **find the work done by friction on the car as it moves from A to B.**



$E_B - E_A = W_{f_k}$

$mgy_f + \frac{1}{2}mv_f^2 - mgy_i = W_{f_k}$

$W_{f_k} = 150(10)(12) + \frac{1}{2}(150)(8^2) - 150(10)(17)$

$= -2700\,J$

b) Find the normal force exerted on the car at point B?

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

$n = \frac{mv^2}{R} - mg = 100\,N$

c) Find the total work done on the car as it moves from A to B.

$W_{total} = \Delta K = \frac{1}{2}m(v_B^2 - v_A^2) = 4800\,J$

Or

$W_{total} = W_{mg} + W_{f_k} = +mg(y_f - y_i) - 2700$

$= 150(10)(5) - 2700 = 4800$

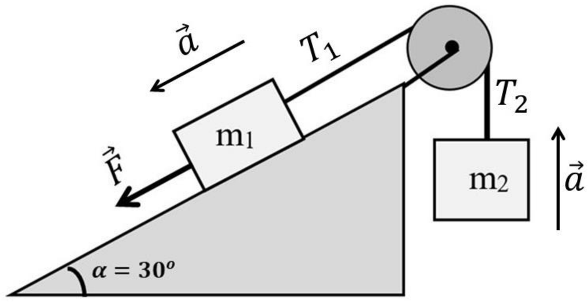
LP3. Two blocks ($m_1 = 12\ kg$, $m_2 = 6\ kg$) are connected by a light rope that passes over a frictionless pulley of radius $R = 0.1\ m$ and moment of inertia (I). The incline is **frictionless.** A constant force $|\vec{F}| = 40\ N$ acts on block m_1, as shown. The two blocks accelerate in the indicated direction with $|\vec{a}| = 1.2\ m/s^2$.

a) Find the tension T_1 in the segment of the rope attached to mass m_1.

$F + m_1 g\ sin\alpha - T_1 = m_1 a$

$T_1 = F + m_1 g\ sin\alpha - m_1 a$

$= 40 + (12)(10)\sin(30) - (12)(1.2) = 85.6\ N$



b) Find the tension T_2 in the segment of the rope attached to mass m_2.

$T_2 - m_2 g = m_2 a$

$T_2 = m_2(g + a) = 67.2\ N$

c) Find the moment of inertia of the pulley (I).

$\alpha = \dfrac{a}{R} = 12\ rad/s^2$

$\sum \vec{\tau} = I\vec{\alpha}$

$T_1 R - T_2 R = I\alpha$

$85.6(0.1) - 67.2(0.1) = I(12) \Rightarrow I = 0.153\ kg \cdot m^2$

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

Q1. If $\vec{A}$ and $\vec{B}$ are **nonzero vectors** and $\vec{A} \cdot \vec{B} = 0$, then which of the following **is always true**.

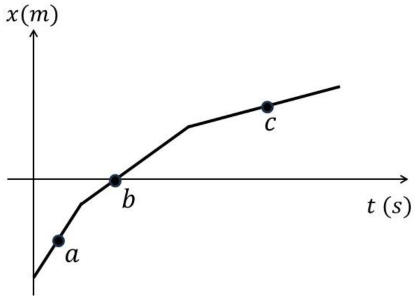
* $\vec{A}$ is parallel to $\vec{B}$.
* $|\vec{A} \times \vec{B}| = |\vec{A}||\vec{B}|$
* $|\vec{A} \times \vec{B}| = 1$
* $|\vec{A} \times \vec{B}| = 0$

Q2. When two objects of different masses collide, **the magnitudes of the impulses they exert on each other are:**

* equal for all collisions
* equal only for elastic collisions
* equal only for inelastic collisions
* always unequal

Q3: The graph shows the position of a particle moving along the x-axis as a function of time. If v_a, v_b, and v_c represent the speeds of the particle at points **a**, **b**, and **c**, respectively, then:

* $v_c > v_b > v_a$
* $v_c > v_a > v_b$
* $v_a > v_c > v_b$
* $v_a > v_b > v_c$



Q4. The angular velocity versus time graph for a point on the rim of a disk rotating about its center is shown. **At which instant of time does the point have the maximum radial acceleration (a_{rad})?**

* t_1
* t_2
* t_3
* t_4