Kuwait University Physics Department

Physics 101

Spring Semester

Final Exam

Monday, June 6, 2022

5:00 PM – 7:00 PM

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

Student's Number: ….…… Section: ……

Choose your Instructor's Name:

Dr. Ahmed Al-Jassar	Dr. Belal Salameh
Dr. Hala Al-Jassar	Dr. Nasser Demir
Dr. Tareq Al Refai	Dr. Ruqayyah Askar
Dr. Abdul Khaleq	Dr. Bedoor Alkurtass

For Instructors use only

Grades:

#	SP1	SP2	SP3	SP4	[illegible]	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 $x = 4 + 24t - 3t^2$, where x is in meters and t is in seconds. **Find the average acceleration of the particle between $t = 1\ s$ and $t = 3\ s$.**

$$v_x(t) = \frac{dx}{dt} = 24 - 6t$$

$$v_x(t = 1\ s) = 24 - 6(1) = 18\ m/s$$

$$v_x(t = 3\ s) = 24 - 6(3) = 6\ m/s$$

$$a_{av-x} = \frac{v_{x_f} - v_{x_i}}{t} = \frac{6 - 18}{2} = -6\ m/s^2$$

SP2. A stone is thrown from the edge of a cliff with a speed of $5\ m/s$ at an angle of 53.1^o above the horizontal, as shown. **With what velocity in unit vector notation does the stone hit the ground?**

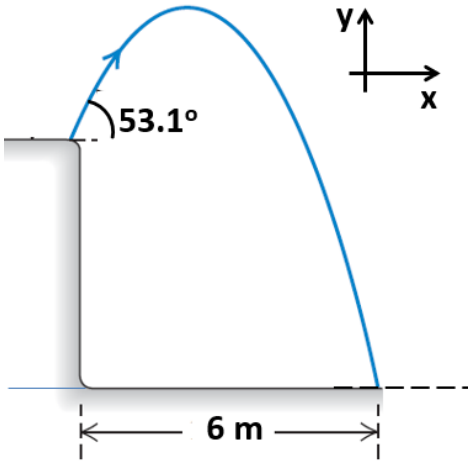
$$v_{x_i} = v_i \cos 53.1^o = 3\ m/s$$

$$v_{y_i} = v_i \sin 53.1^o = 4\ m/s$$

$$\Delta x = v_{x_i} t \Rightarrow t = \frac{\Delta x}{v_{x_i}} = \frac{6}{3} = 2\ s$$

$$v_{y_f} = v_{y_i} - gt = 4 - 10(2) = -16\ m/s$$

$$\vec{v}_f = (3\hat{\imath} - 16\hat{\jmath})\ m/s$$



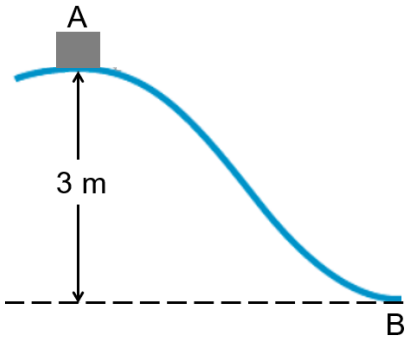
SP3. A particle of mass $4\ kg$ moves along the x-axis under the influence of **a net conservative force**. The potential energy is given by $U(x) = x^4 - 3x^2 + 5$, where x is in meters and U is in Joules. **Find the acceleration of the particle at $x = 1\ m$.**

$$F_x = -\frac{dU}{dx} = -(4x^3 - 6x) = -4x^3 + 6x$$

$$F(x = 1\ m) = -4(1)^3 + 6(1) = 2\ N$$

$$a_x = \frac{F_x}{m} = 0.5\ m/s^2$$

SP4. A box of mass 20 kg **starts from rest at point A** and slides down on **a rough** surface. The work done by friction on the box between point A and point B is $-350\ J$. **Find the box's speed at point B.**



$$E_B - E_A = w_{f_k}$$

$$\frac{1}{2}mv_B^2 - mgy_A = w_{f_k}$$

$$\frac{1}{2}(20)v_B^2 - 20\ (10)(3) = -350$$

$$v_B = 5\ m/s$$

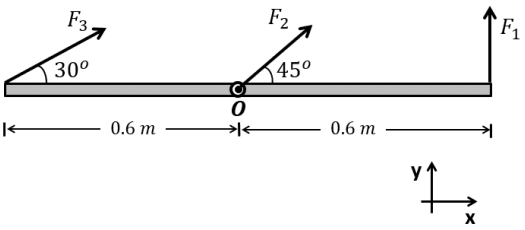
SP5. A stone of mass M is moving with velocity $\vec{v} = (4\hat{\imath} + 6\hat{\jmath})\ m/s$ explodes into two parts (A and B) each of mass $M/2$. The velocity of stone A is $\vec{v}_A = (5\hat{\imath} - 3\hat{\jmath})\ m/s$, **find the velocity of stone B in unit vector notation.**

$$\sum \vec{p}_i = \sum \vec{p}_f$$

$$M\vec{v} = \frac{M}{2}\vec{v}_A + \frac{M}{2}\vec{v}_B$$

$$\vec{v}_B = 2\vec{v} - \vec{v}_A = (8\hat{\imath} + 12\hat{\jmath}) - (5\hat{\imath} - 3\hat{\jmath}) = (3\hat{\imath} + 15\hat{\jmath})\ m/s$$

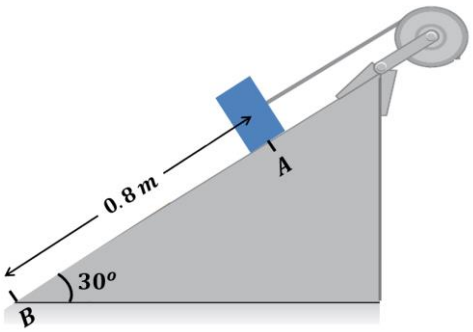
SP6. Three forces of magnitudes, $F_1 = 50\ N, F_2 = 80\ N, and\ F_3 = 140\ N$, act on a uniform rod of length 1.2 m, as shown. **Find the net torque due to these forces about a vertical axis passing through point *O*.** The rod and the three forces lie in the plane of the page.



$$\sum \vec{\tau} = +r_1F_1 \sin 90^o + (0) - r_3F_3 \sin 30^o$$

$$\sum \vec{\tau} = +(0.6)(50)(1) \quad - (0.6)(140) \sin 30^o = -\ 12\ \hat{k}\ N \cdot m$$

SP7. A light cord is wrapped around a pulley ($M = 2\ kg, R = 20\ cm, I = \frac{1}{2}MR^2$) and connected to a block of mass $m = 3\ kg$, as shown. The block is released **from <u>rest</u> at point A** and slides down a **frictionless incline**. **Find the speed of the block at point B.**



$$E_A \quad = \quad E_B$$

$$mgy_A \quad = \quad \frac{1}{2}mv_B^2 + \frac{1}{2}I\omega_B^2$$

$$mg(0.8 \sin 30^o) \quad = \quad \frac{1}{2}mv_B^2 + \frac{1}{2}(\frac{1}{2}MR^2)(\frac{v_B}{R})^2$$

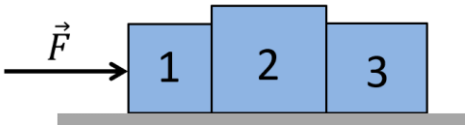
$$0.4\ mg = (\frac{1}{2}m + \frac{1}{4}M)v_B^2$$

$$v_B = \sqrt{\frac{0.4\ mg}{\frac{1}{2}m + \frac{1}{4}M}} = 2.45\ m/s$$

Part II: Long Problems (5 points each)

LP1. Three blocks of wood ($m_1 = 5\ kg, m_2 = 9\ kg, m_3 = 6\ kg$) are in contact on **a rough horizontal surface ($\mu_k = 0.4$)**. A horizontal force $F = 120\ N$ is applied on m_1.

a) Find the acceleration of the system



$$F - \mu_k M_{total} g = M_{total} a$$

$$a = \frac{F - \mu_k M_{total} g}{M_{total}} = \frac{120 - 0.4(200)}{20} = 2\ m/s^2$$

b) Find the magnitude of the force exerted on block 3 by block 2 (F_{23}).

***for block* 3**:

$$F_{23} - \mu_k m_3 g = m_3 a$$

$$F_{23} = \mu_k m_3 g + m_3 a = (0.4)(60) + 6(2) = 36\ N$$

c) Find the magnitude of the net force on m_3.

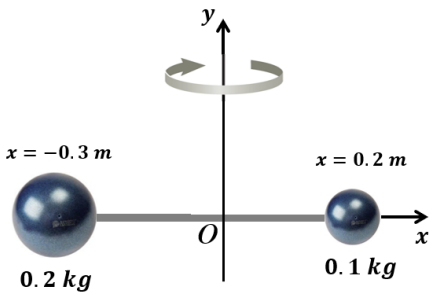
$$\sum F_{on\ m_3} = m_3 a = 12\ N$$

OR

$$\sum F_{on\ m_3} = F_{23} - \mu_k m_3 g = 36 - (0.4)(6)(10) = 12\ N$$

LP2. A system of two particles connected to a rod of length 0.5 m is rotating about the **y-axis**, as shown. The moment of inertia of the system about y-axis is $\boldsymbol{I_{system} = 0.1\ kg \cdot m^2}$. The angular position of the system is given by $\theta(t) = 2.5t^2 - 5t^3$, where θ is in radians and t is in seconds.

a) Find the rotational kinetic energy of the system at $\boldsymbol{t = 2\ s}$.



$$\omega(t) = \frac{d\theta}{dt} = 5t - 15t^2$$
$$\omega(t = 2s) = 5(2) - 15(2^2) = -50\ rad/s$$
$$K_{rot} = \frac{1}{2} I_{system}\omega^2 = \frac{1}{2}(0.1)(50^2) = 125\ J$$

b) Find the net torque of the system about y-axis at $\boldsymbol{t = 2\ s}$.

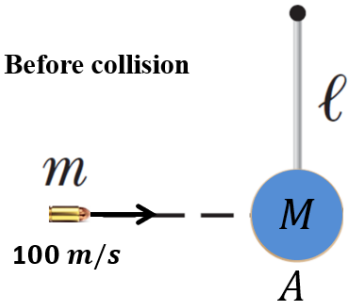
$$\alpha(t) = \frac{d\omega}{dt} = 5 - 30t$$
$$\alpha(t = 2s) = 5 - 30(2) = -55\ rad/s^2$$
$$\vec{\tau} = I\alpha = 0.1(-55) = -5.5\ \hat{j}\ N \cdot m$$

c) Find the moment of inertia of the rod.

$$I_{system} = I_{rod} + \sum m_i r_i^2$$
$$\Rightarrow I_{rod} = I_{system} - \sum m_i r_i^2 = 0.1 - [0.2(0.3^2) + 0.1(0.2^2)] = 0.078\ kg \cdot m^2$$

LP3. A bullet of mass $m = 50\ g$ moves at a speed of $100\ m/s$ makes **a completely inelastic collision** with a pendulum bob of mass $M = 0.45\ kg$. The bob is suspended by a light rope of length $l = 1.2\ m$. **After the impact, the bob swings through a vertical circle**.

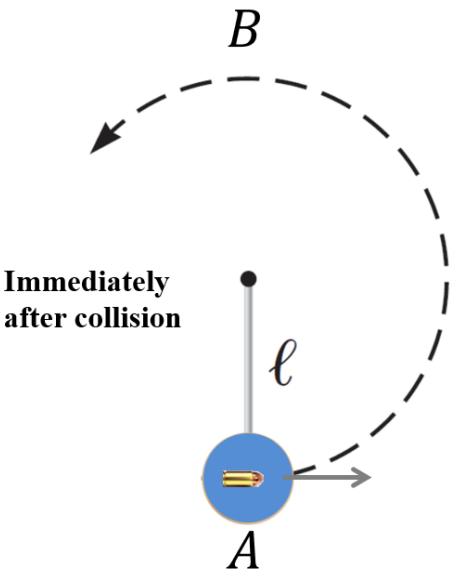
a) Find the speed of the bob immediately after the impact.



$$mv_{1_i} + Mv_{2_i} = (m+M)v_A$$

$$0.05(100) + 0.45(0) = 0.5\ v_A$$

$$v_A = \frac{0.05(100)}{0.5} = 10\ m/s$$



b) Find the speed of the bob at point B.

$$E_A = E_B$$

$$\frac{1}{2}(m+M)v_A^2 = \frac{1}{2}(m+M)v_B^2 + (m+M)g(2l)$$

$$v_B = \sqrt{v_A^2 - 4gl} = \sqrt{10^2 - 4(10)(1.2)} = 7.2\ m/s$$

c) Find the tension in the rope at point B.

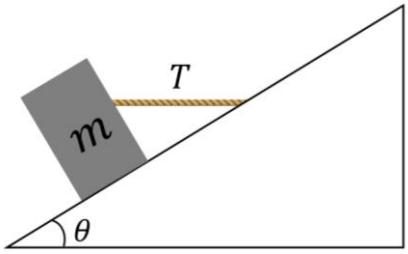
at B:

$$T + (m+M)g = (m+M)(\tfrac{v_B^2}{l})$$

$$T = (m+M)\left(\frac{v_B^2}{l} - g\right) = 16.7\ N$$

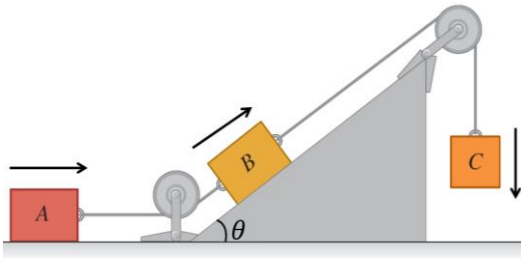
Part III: Questions (Choose the correct answer, one point each)

Q1. A block of mass m is held in place on **a frictionless incline** by **a horizontal** cable with tension T, as shown. What is the tension in the cable?



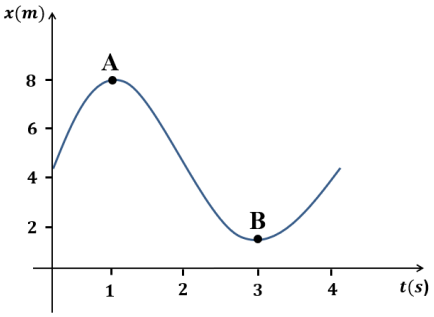
* $T = mg \sin\theta$
* $T = mg \cos\theta$
* $T = mg$
(*) $T = mg \tan\theta$

Q2. Three blocks are connected as shown. The ropes and pulleys are of negligible mass. When released, block *C* moves downward, block *B* moves up the ramp, and block *A* moves to the right. The **work done by gravity** is



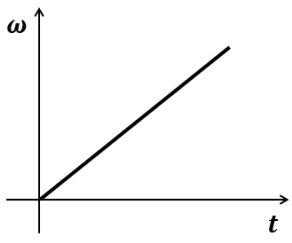
* Positive on all the blocks.
* Negative on all the blocks.
(*) Zero on block A, negative on block B, positive on block C.
* Zero on block A, positive on block B, negative on block C.

Q3. The **position-time** graph of an object traveling along the x-axis is shown in the figure. The **average acceleration** between $t = 1\ s$ (point A) and $t = 3\ s$ (point B) is



(*) zero
* positive
* negative
* cannot be determined

Q4. A disk is rotating with **constant angular acceleration**. It changes its direction of rotation **from clockwise to counter-clockwise**. Which of the following graphs describes its angular velocity?



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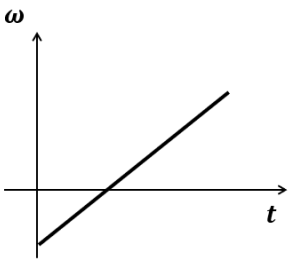

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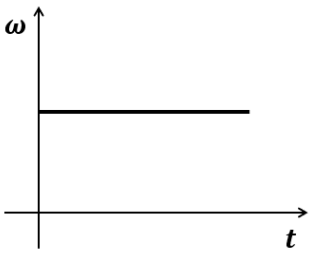

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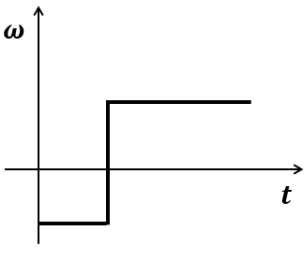

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