Kuwait University Physics Department

Physics 101

Summer Semester

Final Exam

Saturday, July 21, 2018

2:00 pm – 4:00 pm

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

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

Choose your Instructor's Name:

Dr. Hala Al-Jassar
Dr. Fatema Al Dosari

Dr. Tareq Al Refai
Dr. Abdul Khaleq
Dr. Belal Salameh

For Instructors use only

Grades:

#	Q1	[illegible]	[illegible]	Q4	SP1	SP2	SP3	SP4	SP5	SP6	SP7	LP1	LP2	LP3	Total
	1	[illegible]	1	1	3	3	3	3	3	3	3	5	5	5	40
Pts															

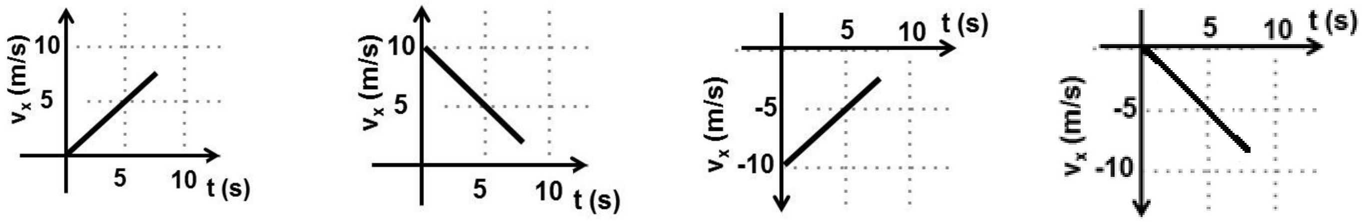
Important:

1. Answer all questions and problems.
2. Full mark = 40 points as arranged in the above table.
   i) 4 **Q**uestions
   ii) 7 **S**hort **P**roblems
   iii) 3 **L**ong **P**roblems.
3. No solution = no points.
4. **Give your final answer in the correct units.**
5. Check the correct answer for each question.
6. Assume g = 10 m/s^2.
7. Mobiles are **strictly prohibited** during the exam.
8. Programmable calculators, which can store equations, are not allowed.
9. **Cheating incidents will be processed according to the university rules.**

GOOD LUCK

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

Q1. A particle moves along the **positive x-axis and <u>slows down</u> at a rate of 1 m/s^2**. The graph which correctly represents its velocity is:



*   ⊛   *   *

Q2. A block is moving **at a constant velocity due north**. **What can you conclude?**

* There is just one force acting on the block toward the north.

⊛ The net force on the block is zero.

* The net force on the block is due north.

* There are only two non-equal forces acting on the block.

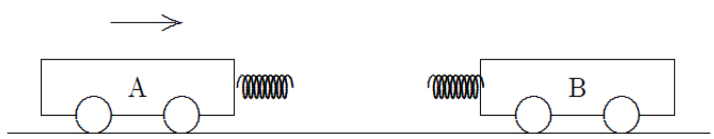
Q3. Two carts (A and B) **with different masses**, collide elastically as shown. Cart A is initially moving to the right and cart B is initially at rest. **At the instant when the separation between the carts is a minimum during the collision, one of the following is true:**

* $v_B = 0$.

* $v_A = 0$.

* $K_A = K_B$

⊛ $(K_A + K_B)$ is minimum.



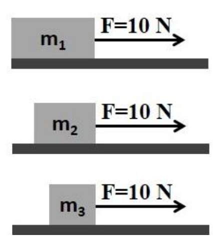
Q4. Three blocks with different masses ($m_1 > m_2 > m_3$) **rest on a frictionless table**. Each block is acted on by a constant horizontal force of magnitude 10 N for 0.1 s, as shown in the figure. **If J_1, J_2 and J_3 are the impulses imparted on m_1, m_2 and m_3, respectively, then one of the following is correct:**

* $J_1 > J_2 > J_3$.

* $J_2 > J_3 > J_1$.

* $J_3 > J_2 > J_1$.

⊛ $J_1 = J_2 = J_3$.



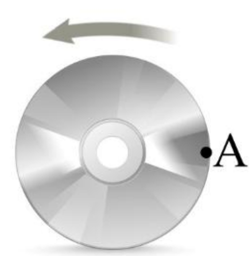
<u>Part II: Short Problems (3 points each)</u>

Sp1. A disc of radius 0.5 m **starts from rest** and rotates with **a constant angular acceleration** of 2 rad/s^2 about its center as shown in the figure. **Find the magnitude of the centripetal acceleration (in m/s^2) of the point A which is at the edge of the disc when it has turned through 1.6 rad.**

$\omega_f^2 = \omega_i^2 + 2\alpha\Delta\theta$

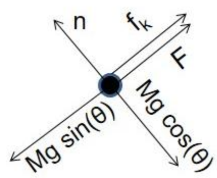
$= 0 + 2(2)(1.6) = 6.4 \text{ (rad/s)}^2$

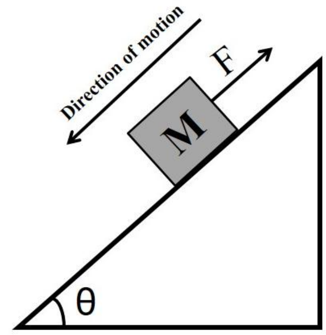
$a_c = R\omega^2 = 0.5(6.4) = 3.2 \text{ m/s}^2$



Answer: $a_c = 3.2\ m/s^2$

SP2. A block of mass M **on a rough incline** is pulled by a constant force F as shown in the figure. If the block **slides down** the incline at a constant speed, draw a free body diagram of this block.





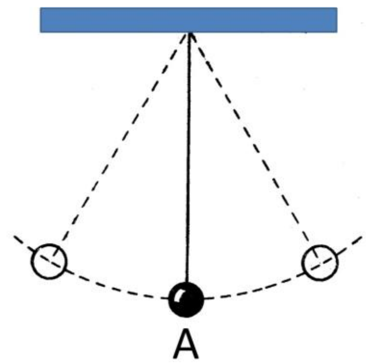
SP3. One end of a 2 m cord is fixed and the other end is attached to a 0.5 kg ball. The ball swings in **a vertical circle** as shown in the figure. If **the speed of the ball at point A is 3 m/s**, **find the tension (in N) in the cord at point A.**

At point A

$$T - mg = m\frac{v^2}{R}$$

$$T = m\left(g + \frac{v^2}{R}\right)$$

$$= 0.5\left(10 + \frac{9}{2}\right) = 7.25\ \text{N}$$



Answer: $T = 7.25\ \text{N}$

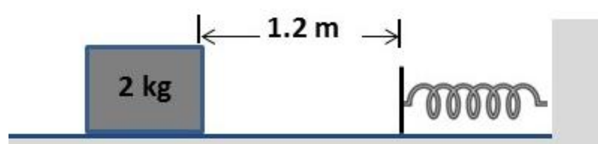
SP4. A spring is fixed at the edge of **a rough table (μ_k=0.3)** as shown in the figure. A 2 kg block is moving with a speed of 4 m/s toward the **relaxed spring** from a point which is at a distance of 1.2 m from it. If the block **stops momentarily** when it has compressed the spring 0.5 m, **what is the work (in J) done by the spring during this compression.**

$$\sum W = \Delta K$$

$$W_{Fs} + W_{fk} = 0 - \frac{1}{2}mv_i^2$$

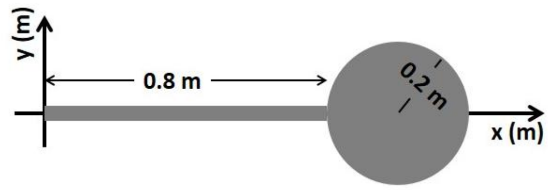
$$W_{Fs} - \mu_k mgd = -\frac{1}{2}mv_i^2$$

$$W_{Fs} = \mu_k mgd - \frac{1}{2}mv^2 = 0.3(2)(10)(1.7) - \frac{1}{2}(2)(4)^2 = -5.8\ \text{J}$$



Answer: $W_{Fs} = -5.8\ \text{J}$

SP5. A uniform rod (m_{rod}=2 kg, L=0.8 m) is connected to a uniform disk (m_{disc}=3 kg, R=0.2 m), as shown in the figure. **Find the x-component of the center of mass of the system as measured from the origin.**



$m_1 = 2\text{kg}$ $x_1 = 0.4$ m

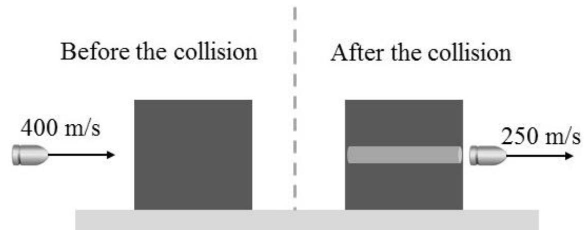
$m_2 = 3\text{kg}$ $x_2 = 1$ m

$$x_{cm} = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2}$$

$$= \frac{2(0.4) + 3(1)}{5} = 0.76 \text{ m}$$

Answer: $x_{cm} = 0.76$ m

SP6. A 2 kg block **rests** on a frictionless surface. A 50 g bullet moving at 400 m/s strikes the block and **emerges from it** with a speed of 250 m/s, as shown in the figure. **What is the speed (in m/s) of the block after the collision?**



$$m_1 v_{1x_1} + m_2 v_{2x_1} = m_1 v_{1x_f} + m_2 v_{2x_f}$$

$$0.05\ (400) + 0 = 0.05\ (250) + 2v_{2x_f}$$

$$v_{2x_F} = \frac{0.05\ (400) - 0.05(250)}{2}$$

$$= 3.75 \text{ m/s}$$

Answer: $v_{2x_F} = 3.75$ m/s

SP7. Two blocks are connected by a light rope that passes over a pulley, as shown in the figure. The system is **released from rest** and the rope does not slip on the pulley rim. If the speed of the 4 kg block is 3 m/s just before it strikes the ground**, calculate the rotational kinetic energy (in J) of the pulley at that instant.**

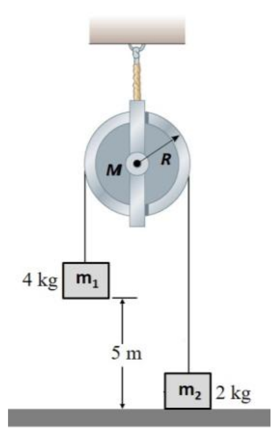
$$E_i = E_f$$

$$m_1 gh = m_2 gh + \frac{1}{2}(m_1 + m_2)v_f^2 + K_{rot}$$

$$K_{rot} = (m_1 - m_2)\ gh - \frac{1}{2}\ (m_1 + m_2)\ v_f^2$$

$$= 2(10)(5) - \frac{1}{2}\ (6)(3)^2$$

$$= 73 \text{ J}$$



Answer: $K_{rot} = 73$ J

Part III: Long Problems (5 points each)

LP1. A single force (F) is acting on a 0.5 kg box. The velocity of the box is given by $\vec{v}(t) = [40\,\hat{i} + (20 - 10t)\hat{j}]$ m/s $(0 \le t \le 4s)$, where **t** is in seconds.

a) Find the force F (in N) in unit vector notation at t=3 s.

$\vec{a} = \frac{d\vec{v}}{dt} = -10\,\hat{j}\ m/s^2$

$\Sigma\,\vec{F} = \vec{F} = m\vec{a}$

$\vec{F} = 0.5\,(-10\,\hat{j}) = -5\,\hat{j}\ N$

OR

$\vec{v}\,(3\ s) = (40\,\hat{i} - 10\hat{j})\ m/s$

$\vec{v}\,(0\ s) = (40\,\hat{i} + 20\hat{j})\ m/s$

$\vec{J} = m(\vec{v}_f - \vec{v}_i) = 0.5(-30\hat{j}) = -15\hat{j}\ N \cdot s$

$\vec{F} = \frac{\vec{J}}{\Delta t} = \frac{-15\hat{j}}{3-0} = -5\hat{j}\ N$

Answer: $\vec{F} = -5\,\hat{j}\ N$

b) Find the power (in W) which is delivered by the force F to the box at t=3 s.

$\vec{v}\,(3s) = 40\,\hat{i} + \big(20 - 10(3)\big)\hat{j} = (40\,\hat{i} - 10\hat{j})\ m/s$

$P = \vec{F} \cdot \vec{v} = (-5\hat{j}) \cdot (40\hat{i} - 10\hat{j}) = +50\ W$

Answer: $P = +50\ W$

c) Find the total work (in J) which is done on the box during the time interval from t=0 s to t= 2 s.

$\Sigma w = \Delta k = \frac{1}{2} m\big(v^2(2\ s) - v^2(0\ s)\big)$

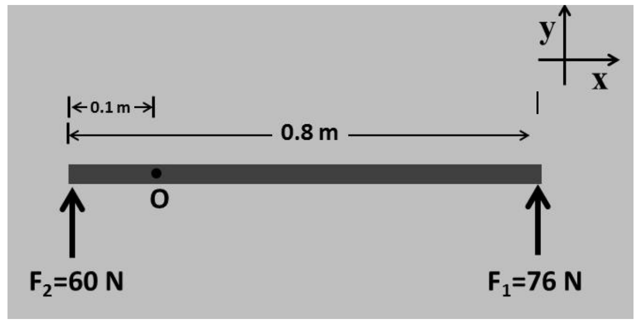
$\vec{v}(2\ s) = 40\,\hat{i} + (20 - 20)\hat{j} = 40\,\hat{i}\ m/s \Longrightarrow v^2(2\ s) = 1600\ \left(\frac{m}{s}\right)^2$

$\vec{v}(0\ s) = (40\hat{i} + 20\,\hat{j})\frac{m}{s} \Longrightarrow v^2(0\ s) = 2000\ \left(\frac{m}{s}\right)^2$

$\Sigma W = \frac{1}{2}(0.5)(1600 - 2000) = -100\ J$

Answer: $\Sigma W = -100\ J$

LP2. A uniform rod of a length of 0.8 m and a mass of 6 kg ($\mathbf{I_{cm} = \frac{1}{12}ML^2}$) lies on **a horizontal frictionless table**, as shown in the figure. The rod is free to rotate about a pivot which passes through it at the point O. Two horizontal forces are acting on the rod as shown.



a) Calculate the moment of inertia (in $\mathbf{kg\,m^2}$) of the rod about the point O.

$$I_o = I_{cm} + Md^2$$
$$= \frac{1}{12}ML^2 + Md^2$$
$$= \frac{1}{12}(6)(0.8)^2 + 6(0.3)^2 = 0.86\ \mathrm{kg\,m^2}$$

Answer: $I_o = 0.86\ \mathrm{kg\,m^2}$

b) Find the net torque (in N · m) on the rod.

$$\Sigma\vec{\tau} = F_1R_1 - F_2R_2$$
$$= 76\,(0.7) - 60\,(0.1) = +47.2\ \mathrm{N\cdot m}$$

Answer: $\Sigma\vec{\tau} = +47.2\ \mathrm{N\cdot m}$

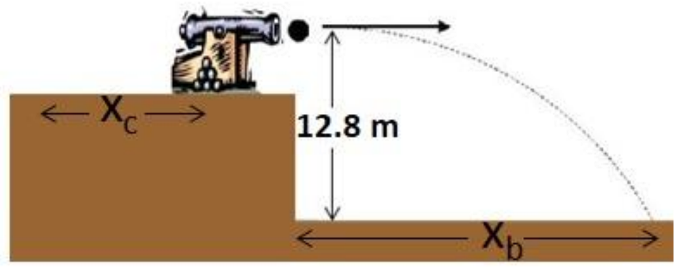
c) Find the magnitude of the initial angular acceleration (in rad/s²) of the rod.

$$|\Sigma\tau| = I|\alpha| \Longrightarrow |\alpha| = \frac{|\Sigma\tau|}{I}$$
$$|\alpha| = \frac{47.2}{0.86} = 54.9\ \mathrm{rad/s^2}$$

Answer: $|\alpha| = 54.9\ \mathrm{rad/s^2}$

LP3: A cannon of mass M = 200 kg **rests** on the top of a vertical cliff fires a 10 kg cannon ball horizontally at a speed of 80 m/s, as shown in the figure.

a) Find the recoil speed (in m/s) of the cannon.



$$m_1 v_{1x_i} + m_2 v_{2x_i} = m_1 v_{1x_f} + m_2 v_{2x_f}$$

$$0 + 0 = 200\ v_{1x_f} + 10\ (80)$$

$$V_{1x_f} = \frac{-800}{200} = -4\ m/s$$

$$\Rightarrow\ |v_{1x_f}| = 4\ \text{m/s}$$

Answer: $|v_{1x_f}| = 4$ m/s

b) If the cannon slides back and stops 0.8 s after firing the cannon ball. Assuming a constant friction force, find the distance (x_c) (in m) which is travelled by the cannon.

$$v_{x_f} = v_{x_i} + a_x t$$

$$0 = 4 + a_x(0.8)\ \Rightarrow\ a_x = -5\ \text{m/s}^2$$

$$v_{x_f}^2 = v_{x_i}^2 + 2a_x \Delta x$$

$$0 = (4)^2 + 2(-5)\Delta x \quad \Rightarrow\ x_c = \Delta x = 1.6\ \text{m}$$

Answer: $x_c = 1.6$ m

c) Find the horizontal distance (x_b) (in m) which is travelled by the cannon ball before it hits the ground.

$$\Delta y = -12.8\text{m}$$

$$\Delta y = V_{y_i} t - \frac{1}{2} g t^2$$

$$-12.8 = 0 - 5t^2$$

$$t = \sqrt{\frac{12.8}{5}} = 1.6\ \text{s}$$

$$x_b = \Delta x = V_{x_i} t = 80\ (1.6) = 128\ \text{m}$$

Answer: $x_b = 128$ m