Kuwait University **Physics Department**

Physics 101

Spring Semester
Final Exam
Monday, May 13, 2019
12:00 noon – 2:00 pm

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

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

Choose your Instructor's Name:

Prof. Yacoub Makdisi	Dr. Tareq Al Refai
Dr. Ahmed Al-Jassar	Dr. Belal Salameh
Dr. Hala Al-Jassar	Dr. Abdel Khaleq
Dr. Nasser Demir	

For Instructors use only

Grades:

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

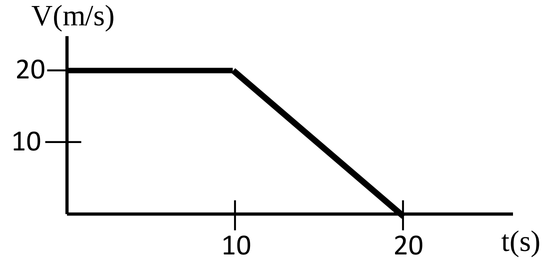
Important:

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. **Use SI 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. **Please write down your final answer in the box shown in each problem.**
10. **Cheating incidents will be processed according to the university rules.**

GOOD LUCK

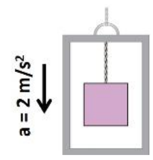
Part I: Questions (Choose the correct answer, one point each)

Q1. The graph shows (v versus t) for a car moving along **a straight line**. **The average acceleration of the car from t = 0 s to t = 20 s is:**



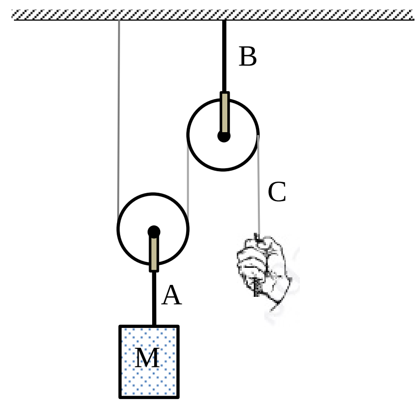
* $+1.0\ m/s^2$
* $-1.0\ m/s^2$
* $-1.2\ m/s^2$
* $+1.2\ m/s^2$

Q2. A string is attached to the ceiling of an elevator and holds a block of 40 N weight. If the elevator starts to **accelerate downward at 2 m/s²**, then the **tension in the string is:**



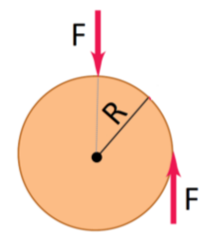
* 48 N   * 40 N   *38 N   *32 N

Q3. A box M is pulled upward at a constant speed. The pullies are massless and the cords are light. If T_A, T_B and T_C are the tensions in the cords A, B and C respectively, then



* $T_C = T_A = T_B$
* $T_C = (T_A - T_B)$
* $T_C = \frac{1}{2} T_A$
* $T_C = \frac{1}{2} (T_A + T_B)$

Q4. A solid disc of radius R is free to rotate about an axis passing through the C.M. and perpendicular to the disc as shown. Two applied forces of equal magnitude F act on the disc. **The magnitude of the net torque about this axis is**



* $2RF$
* RF
* $\frac{1}{2}RF$
* zero

Part II: Short Problems (3 points each)

SP1. You start driving your car at time 7:14 a.m. from a point which is 3 km west of your house. At time 7:26 a.m., your car is 15 km at 30° east of north from your house. **Find the average velocity** (in m/s) of your car during this time interval **in unit vector notation**.

$$\vec{r}_i = -3000\ i\ m$$

$$\vec{r}_f = (15000 \sin 30^o\ \hat{\imath} + 15000\ cos30^o \hat{\jmath})\ m = (7500\ \hat{\imath} + 12990.4\ \hat{\jmath})\ m$$

$$\Delta\vec{r} = \vec{r}_f - \vec{r}_i = (10500\ \hat{\imath} + 12990.4\ \hat{\jmath})\ m$$

$$\vec{V}_{av} = \frac{\Delta\vec{r}}{\Delta t} = \frac{10500\ \hat{\imath} + 12990.4\ \hat{\jmath}}{12(60)} = (14.6\ \hat{\imath} + 18\ \hat{\jmath})m/s$$

Answer: $\vec{V}_{av} = (14.6\ \hat{\imath} + 18\ \hat{\jmath})m/s$

SP2. Two balls of **equal mass** undergo **a perfectly elastic head-on collision**. If one ball's initial speed was 2 m/s and the other's was 3.6 m/s in the opposite direction, **what will be their speeds (in m/s) after the collision?**

$$V_{1i} = 2\,m/s,\ V_{2i} = -3.6\,m/s$$
$$V_{2f} - V_{1f} = V_{1i} - V_{2i} = 2 - -3.6 = 5.6\,m/s \Rightarrow\ V_{2f} = V_{1f} + 5.6$$

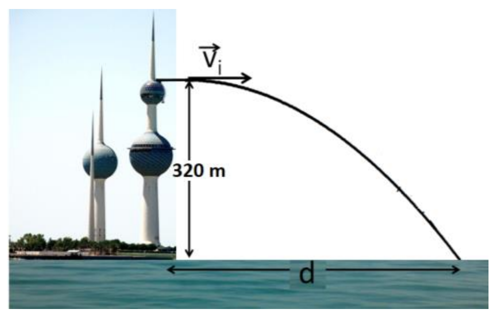
$$V_{1i} + V_{2i} = V_{1f} + V_{2f}$$
$$2 - 3.6 = V_{1f} + (V_{1f} + 5.6) \Rightarrow -1.6 = 2V_{1f} + 5.6$$
$$\Rightarrow\ V_{1f} = -3.6\,m/s$$

$$V_{2f} = V_{1f} + 5.6 = 2m/s$$
$$V_{2f} = 2m/s$$

Answer: $V_{1f} = 3.6\,m/s$

$V_{2f} = 2m/s$

SP3. A bullet is fired**, horizontally**, toward the sea from the top of Kuwait tower that is 320 m above the sea. The initial speed of the bullet is 250 m/s. **How far from the base of the tower (d) (in m) does the bullet strike the surface of the sea?**

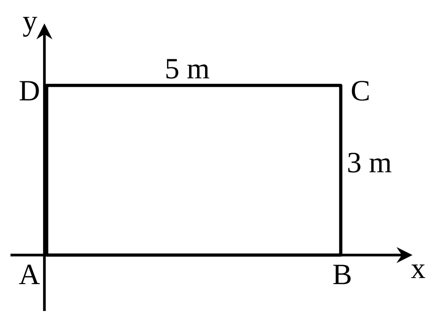


$$\Delta \boldsymbol{y} = V_{oy}t - \frac{1}{2}\,gt^2 \qquad \Longrightarrow\ -320 = 0 - 5t^2$$
$$\therefore t^2 = 64\ \Longrightarrow t = 8\,sec.$$
$$d = \Delta x = V_x t \qquad \Longrightarrow \qquad d = 250 \times 8 = 2000\,m$$

Answer: $d = 2000\,m$

SP4. A conservative force $\vec{F} = (3\hat{\imath} + 4\hat{\jmath})\,N$ is applied to move a particle **from point A to point C** (see the figure).

What is the work (in J) done by $\vec{F}$?



$$\Delta\vec{r} = 5\hat{\imath} + 3\hat{\jmath}$$

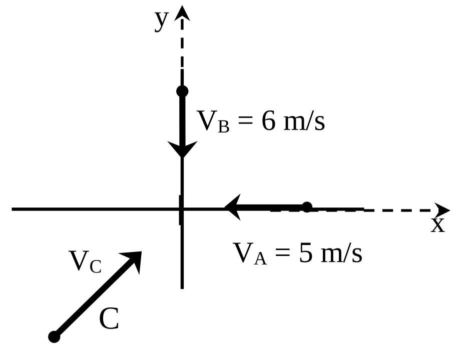
$$\therefore W = \vec{F}\cdot\Delta\vec{r}$$

$$\because W = (3\hat{\imath} + 4\hat{\jmath})\cdot\ (5\hat{\imath} + 3\hat{\jmath})$$

$$= 15 + 12 = 27\,J$$

Answer: $W = 27\,J$

SP5. Three blocks of **equal mass** are approaching the origin as they slide on a frictionless air table. The initial velocities of block A and block B are given in the figure. All blocks arrived at the origin at the same time. They **stick together** and move with a speed of **1 m/s in the positive x axis**. **Calculate the initial velocity (in m/s) of block C in unit vector notation.**



$$\vec{P_i} = \vec{P_f}$$
$$m\,\vec{V_A} + m\,\vec{V_B} + m\,\vec{V_C} = 3m\,\vec{V_f}$$
$$\vec{V_A} + \vec{V_B} + \vec{V_C} = 3\,\vec{V_f}$$
$$-5\hat{i} - 6\hat{j} + \vec{V_C} = 3\hat{i}$$
$$\therefore \vec{V_C} = (8\hat{i} + 6\hat{j})\text{ m/s}$$

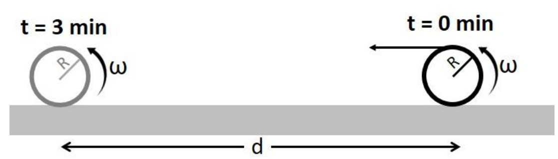
Answer: $\vec{V_C} = (8\hat{i} + 6\hat{j})m/s$

SP6. (From **SP5**) Find the position vector (in m) for each block and for their center of mass ($\vec{r}_A, \vec{r}_B, \vec{r}_C, \vec{r}_{cm}$) **3 s before the collision.**

$$\vec{r_A} = 15\hat{i}\,m$$
$$\vec{r_B} = 18\hat{j}\,m$$
$$\vec{r_C} = (-24\hat{i} - 18\hat{j})\,m$$
$$\vec{r}_{cm} = -3\hat{i}\,m$$

Answer: $\vec{r_A} = 15\hat{\imath}\,m$
$\vec{r_B} = 18\hat{\jmath}\,m$
$\vec{r_C} = (-24\hat{\imath} - 18\hat{\jmath})\,m$
$\vec{r}_{cm} = -3\hat{i}\,m$

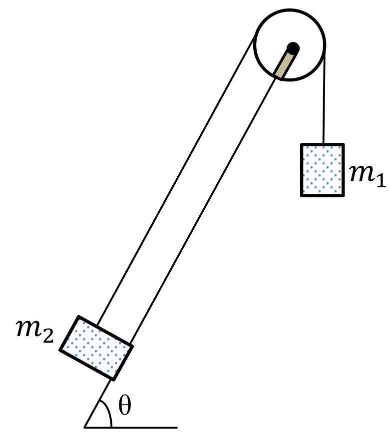
SP7. A 2 kg wheel (R = 0.6 m) is rolling without slipping on a horizontal floor at **constant angular speed** of 4 rad/s. **Calculate the distance (d) (in m) traveled by the wheel in 3 minutes.**



$$\Delta\theta = \omega t = 4(180) = 720\,rad$$
$$s = r\Delta\theta = 0.6(720) = 432\,m$$

Answer: s $= 432\,m$

Part III: Long Problems (5 points each)



LP1. In the figure $m_1 = 6\ kg,\ \ m_2 = 4\ kg$ and $\theta = 53.1^\circ$. The system is released from rest, and m_1 moves **downward with constant acceleration of $0.5\ m/s^2$. The pulley is massless and frictionless.**

a) Calculate the tension T (in N) in the cord.

$m_1 g - T = m_1 a$

$T = m_1 g - m_1 a$

$= 60 - 3 = 57\ N$

Answer: $T = 57\ N$

b) Calculate the friction force (in N) acting on block m_2.

$T - m_2 g \sin\theta - f_k = m_2 a$

$57 - 32 - f_k = 2$

$f_k = 23\ N$

Answer: $f_k = 23\ N$

c) How long (in s) will it take m_1 to move down a distance of 9 m?

$\Delta y = V_{oy} t - \frac{1}{2}\ a t^2$

$-9 = 0 - \frac{1}{2}\left(\frac{1}{2}\right) t^2$

$t^2 = 36 \quad\quad t = 6\ sec$

Answer: $t = 6\ sec$

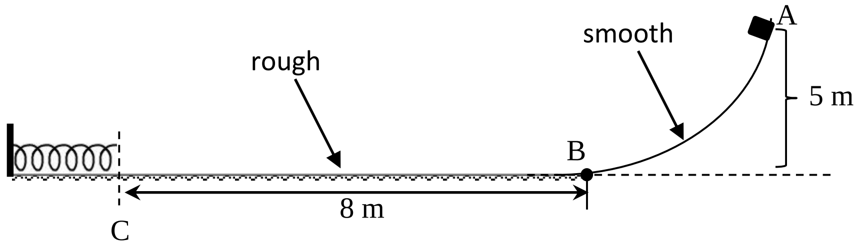
d) What average power (in watt) is produced by friction as the block m_1 moves 9 m downward?

$$p = \frac{W_{f_k}}{\Delta t} = \frac{-f_k d}{\Delta t}$$

$$= \frac{-23(9)}{6} = -34.5\ \text{watt}$$

Answer: $p = -34.5$ watt

LP2. A 4 kg block is **released from rest at point A**. The block slides down to pass point B which is 8 m from a spring as shown. The block hits the spring with speed 6 m/s. **The curved track is smooth and the horizontal track is rough.**



a) What is the speed (in m/s) of the block when it passes point B?

$$E_B = E_A$$

$$\frac{1}{2}\, mV_B^2 = mg\, h_A$$

$$V_B = \sqrt{2g\, h_A} = 10\ m/s$$

Answer: $V_B = 10\ m/s$

b) Calculate the frictional force (in N) acting on the block.

$$\Delta k = w_{f_k}$$

$$\frac{1}{2}\, m\,(V_C^2 - V_B^2) = -f_k d$$

$$\frac{1}{2}\,(4)(36 - 100) = -8 f_k$$

$$f_k = 16\ \ N$$

Answer: $f_k = 16\ \ N$

c) If the block compresses the spring to a maximum compression of 40 cm, what is the spring constant k (in N/m)?

$$\Delta K = W_s + W_f$$

$$0 - \frac{1}{2} mV_C^2 = -\frac{1}{2} kx^2 - f_k x$$

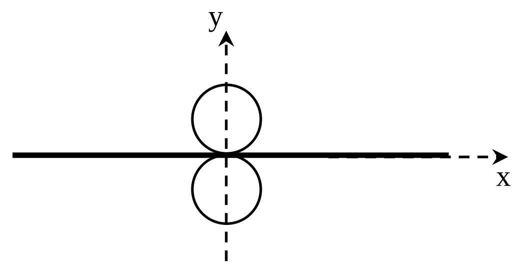
$$-72 = -0.08k - 6.4$$

$$0.08k = 65.6 \implies k = 820\ N/m$$

Answer: $k = 820\ N/m$

LP3. Two **identical uniform rings** each of mass m=0.5 kg and radius R = 20 cm are connected to **the center** of a uniform rod (L = 1.2 m and M = 4 kg), as shown. The moments of inertia of the ring and of the rod about their centers of mass, respectively are $I_{cm}(ring) = mR^2$ and $I_{cm}(rod) = \frac{1}{12}ML^2$.

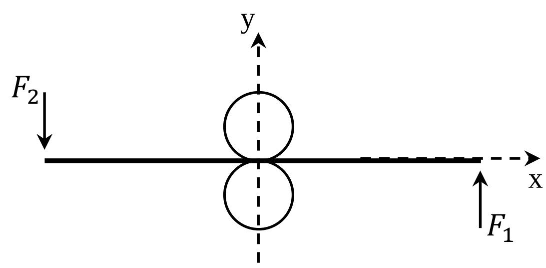
a) Calculate the moment of inertia (in kg m^2) of this system if it rotates about the z-axis.



$$I = 2I_{ring} + I_{rod}$$
$$= 2(mR^2 + mR^2) + \frac{1}{12} M\, L^2$$
$$= 4(0.5 \times 0.2^2) + \frac{4(1.2)^2}{12}$$
$$= 0.08 + 0.48 = 0.56 \;\; kg\, m^2$$

Answer: $I = 0.56 \;\; kg\, m^2$

b) Two forces $F_1 = 3$ N and $F_2 = 2$ N are applied at the ends of the rod as shown. Find the magnitude and direction of the initial torque (in N. m) acting on the system.



$$\tau = 0.6\, F_1 + 0.6\, F_2$$
$$= 1.8 + 1.2 = 3\; N.m$$

out of the page

Answer: $\tau = 3\; N.m$ out of the page

c) Find the initial angular acceleration (in rad/s^2) of the system.

$$\sum \tau = I\alpha \;\Rightarrow \alpha = \frac{\sum \tau}{I} = \frac{3}{0.56} = 5.4\, rad/s^2$$

Answer: $\alpha = 5.4\, rad/s^2$