Kuwait University **Physics Department**

Physics 101

Summer Semester

Final Exam

Monday, August 07, 2017

2:00 pm – 4:00 pm

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

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

Choose your Instructor's Name:

Prof. Yacoub Makdisi
Dr. Hala Al-Jassar
Dr. Fatema Al Dosari
Dr. Belal Salameh

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. **Cheating accidents will be processed according to the university rules.**

GOOD LUCK

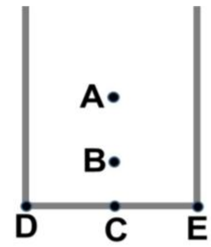
Part I: Questions (Choose the correct answer, one point each)

Q1. Two objects with masses m_1 and m_2 ($\mathbf{m_1 \neq m_2}$) are observed to have the same kinetic energy, **which of the following statements must be true?**

* $m_1V_1 = m_2V_2$ * $m_1V_1+m_2V_2 = 0$ * $V_1 = V_2$

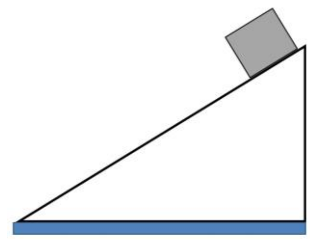
* V_1 and V_2 should have the same direction (*) None of the above.

Q2. A thick uniform wire is bent into the shape shown in the figure. **Which point indicates the location of the center of mass of the wire?**



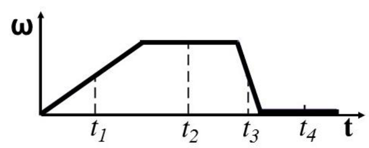
* **A** (*) **B** * **C** * **D** * **E**

Q3. A block slides down a frictionless ramp as shown in the figure, then **one of the following sentences is correct about its kinetic energy (K) potential energy (U) and total mechanical energy (E).**



* **K decreases; U increases and E stays constant.**
(*) **K increases; U decreases and E stays constant.**
* **K decreases; U increases and E increases.**
* **K increases; U decreases and E increases.** * **K increases; U stays constant and E stays constant.**

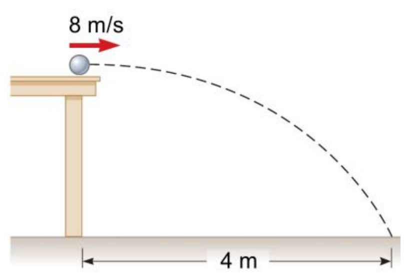
Q4. The angular velocity versus time for a point on the rim of a disk rotating about its center is shown in the figure. **At which instant of time the point will have the highest radial acceleration?**



* **t_1** (*) **t_2** * **t_3** * **t_4**
* **The radial acceleration is constant over the entire period.**

Part II: Short Problems (3 points each)

SP1. A ball is **projected horizontally** from the edge of a table with speed of 8 m/s and touches the ground 4 m from the table as shown in the figure. **What is the speed (in m/s) of the ball just before it touches the ground?**



$$\Delta x = V_{xi}t \;\Rightarrow\; t = \frac{\Delta x}{V_{xi}} = \frac{4}{8} = 0.5 \text{ s}$$

$$V_{yf} = V_{yi} - gt = 0 - 10(0.5) = -5 \text{ m/s}$$

$$V_{xf} = V_{xi} = 8 \text{ m/s}$$

$$|V_f| = \sqrt{(-5)^2 + (8)^2} = 9.4 \text{ m/s}$$

Answer: $|V_f| = 9.4$ m/s

SP2. The potintial energy associated with a conservative force is given by: $U(x) = 4x^2 - 12y + 6$, where U is in Joules and x and y are in meters. **Find the force (in N) (in unit vector notation) and the magnitude of the force at x=2 m, y=4 m.**

$$F_x = -\frac{\partial U}{\partial x} = -8x\ \mathrm{N}$$

$$F_y = -\frac{\partial U}{\partial y} = +12\ \mathrm{N}$$

$$\vec{F}(x,y) = (-8x\,\hat{\imath} + 12\,\hat{\jmath})\mathrm{N} \ \Rightarrow\ \vec{F}(2,4) = (-16\,\hat{\imath} + 12\,\hat{\jmath})\mathrm{N}$$

$$|\vec{F}(2,4)| = \sqrt{(-16)^2 + (12)^2} = 20\ N$$

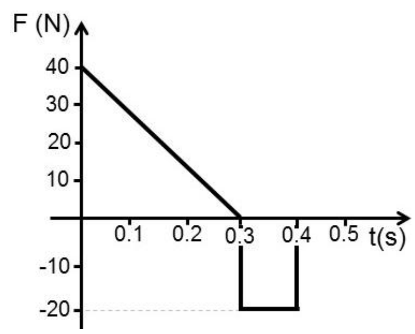
Answer: $|\vec{F}(2,4)| = 20\ N$

SP3. The only force acting on a 2 kg object moving along the x-axis is shown in the figure. **What is the velocity (in m/s) of this object at t=0.4 s if its initial velocity at t= 0 s is +3 $\hat{\imath}$ m/s?**

$$\Delta p = \text{Area} = 0.5(0.3)(40) - 0.1(20) = 4\ \mathrm{N\cdot s}$$

$$\Delta p = m(V_f - V_i) \ \Rightarrow\ V_f = \frac{\Delta p}{m} + V_i = \frac{4}{2} + 3 = 5\ \mathrm{m/s}$$

$$\vec{V_f} = 5\,\hat{\imath}\ \mathrm{m/s}$$



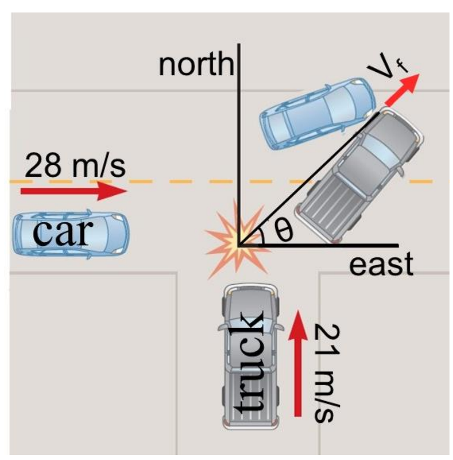
Answer: $\vec{V_f} = 5\,\hat{\imath}\ \mathrm{m/s}$

SP4. A 1200 kg car, travelling east at 28 m/s collides with a 1600 kg truck travelling north at 21 m/s. After the collision, the vehicles stick together and move at an angle θ north of east as shown in the figure. **What is the speed (in m/s) of the center of mass of the two vehicles after the collision?**

$$\vec{V}_{cmi} = \vec{V}_{cmf}$$

$$\vec{V}_{cmi} = \frac{m_1\vec{V}_{1i} + m_2\vec{V}_{2i}}{m_1 + m_2} = \frac{1200(28\,\hat{\imath}) + 1600(21\,\hat{\jmath})}{2800} = (12\,\hat{\imath} + 12\,\hat{\jmath})m/s$$

$$|\vec{V}_{cmi}| = |\vec{V}_{cmf}| = \sqrt{(12)^2 + (12)^2} = 17\ m/s$$

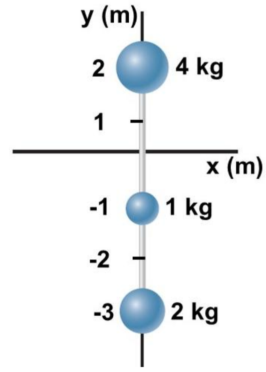


Answer: $|\vec{V}_{cmf}| = 17\ m/s$

SP5. Three small masses are connected by a rod **with neglegable mass** as shown in the figure.

a) What is the moment of inertia (in kg m^2) of the system if it rotates <u>about the x-axis?</u>

b) What is the moment of inertia (in kg m^2) of the system if it rotates <u>about the y-axis?</u>



a) $I_x = \sum m_i r_{ix}^2 = (4)(2)^2 + (1)(1)^2 + (2)(3)^2 = 35 \text{ kg m}^2$

b) $I_y = \sum m_i r_{iy}^2 = \text{Zero} \qquad (r_{1y} = r_{2y} = r_{3y} = 0)$

Answer: $I_x = 35 \text{ kg m}^2$

Answer: $I_y = \text{Zero}$

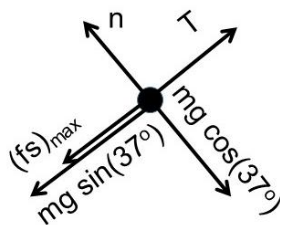
SP6. A 900 kg car is held on **a rough ramp** (μ_k=0.3, μ_s=0.45) by a light cable as shown in the figure . **Find the <u>minimum tension</u> (in N) in the cable in order to hold the car.**

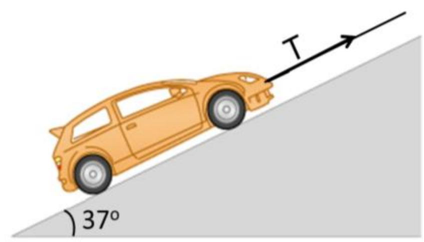
$n = \text{mg}\cos(37^o)$

$T_{min} = \text{mg}\sin(37^o) + (f_s)_{max}$

$= \text{mg}\sin(37^o) + \mu_s \text{ mg}\cos(37)$

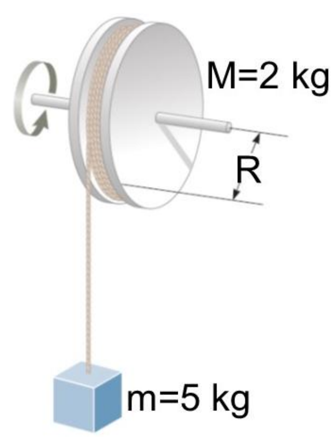
$= 8650.8 \text{ N}$





Answer: $T_{min} = 8650.8 \text{ N}$

SP7. A 5 kg block is attached to the free end of a light string which is wrapped around a disk (R=0.25 m, M=2 kg, $I = \frac{1}{2}MR^2$). The disk is free to rotate about the horizontal axis passing through its center as shown in figure. The block is **released from rest** when it is 6 m above the floor. **Find <u>the speed (in m/s) of the block just before it touches the floor.</u>**



$$\sum E_i = \sum E_f$$

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

$$mgh = \frac{1}{2}mV_f^2 + \frac{1}{2}\left(\frac{1}{2}MR^2\right)\left(\frac{V_f}{R}\right)^2$$

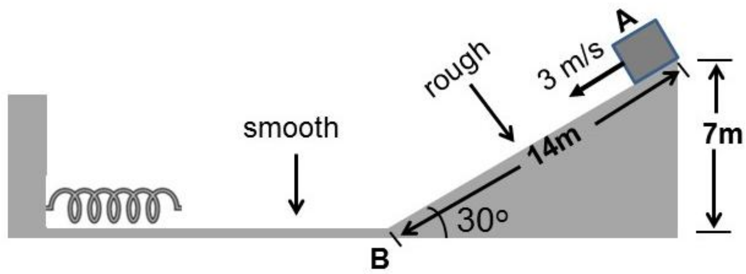
$$V_f = \sqrt{\frac{mgh}{\frac{1}{2}m + \frac{1}{4}M}} = 10 \ m/s$$

Answer: $V_f = 10 \ m/s$

Part III: Long Problems (5 points each)

LP1: A 2 kg block is **projected with a speed of 3 m/s** at point A from the top of a rough incline (μ_k=0.2) then it moved on a smooth horizontal surface and finally compressed a relaxed spring (k= 800 N/m) as shown in the figure.

a) Find the speed (in m/s) of the block at the bottom of the incline (at point B).



$$E_f - E_i = -f_k d$$

$$\frac{1}{2}mV_f^2 - \left(\frac{1}{2}mV_i^2 + mgh\right) = -\mu_k mg\cos(\theta)\, d$$

$$V_f = \sqrt{2gh + V_i^2 - 2gd\,\mu_k \cos(30^o)} = 10\ m/s$$

Answer: $V_f = 10\ m/s$

b) Find the maximum compression (in m) of the spring.

$$\frac{1}{2}mV^2 = \frac{1}{2}kx_{max}^2$$

$$x_{max} = \sqrt{\frac{mV^2}{k}} = \sqrt{\frac{2\,(10)^2}{800}} = 0.5\ m$$

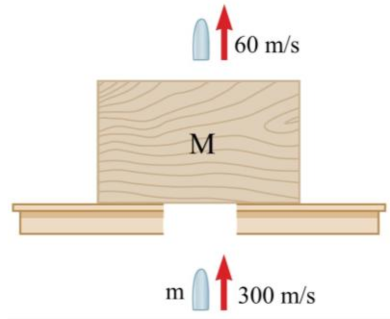
Answer: $x_{max} = 0.5\ m$

c) Find the work (in J) done by the spring on the block as the spring is compressed to the maximum compression.

$$W_{F_s} = -\frac{1}{2}kx_{max}^2 = -100\ J$$

Answer: $W_{F_s} = -100\ J$

LP2. A 0.2 kg wooden block rests on a table over a large hole. A 5 g bullet with an initial velocity **of 300 m/s** is fired upward into the bottom of the block and passes through the block. **The bullet emerges from the block with a velocity of 60 m/s upward** as shown in the figure.



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

$$\sum p_{yi} = \sum p_{yf}$$

$$mV_{1i} + 0 = mV_{1f} + MV_{2f}$$

$$V_{2f} = \frac{m(V_{1i} - V_{1f})}{M} = \frac{0.005(300 - 60)}{0.2} = 6\ m/s$$

Answer: $V_{2f} = 6\ m/s$

b) Find the maximum height that the block will reach after the collision.

$$V_{yf}^2 = V_{yi}^2 - 2g(\Delta y)$$

$$0 = (6)^2 - 2(10)(h_{max}) \Rightarrow h_{max} = 1.8\ m$$

Answer: $h_{max} = 1.8\ m$

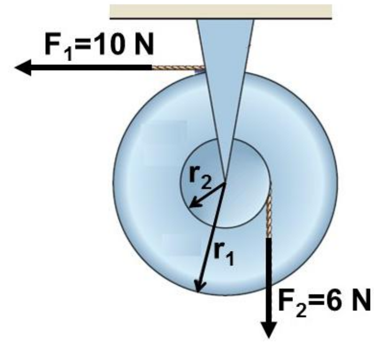
c) Find the amount of dissipated kinetic energy during the collision.

$$\Delta K = \frac{1}{2}mV_{1f}^2 + \frac{1}{2}MV_{2f}^2 - \frac{1}{2}mV_{1i}^2$$

$$= \frac{1}{2}(0.005)(60)^2 + \frac{1}{2}(0.2)(6)^2 - \frac{1}{2}(0.005)(300)^2 = -212.4\ \text{J}$$

Answer: $\Delta K = -212.4$ J

LP3. A single piece solid wheel (made of two disks r_1=0.5 m, r_2=0.25 m) has a moment of inertia I=0.5 kg.m^2. The wheel is free to rotate about a horizontal frictionless axis through its center. Two constant forces are applied to two ropes which are wrapped around the two disks as shown in the figure.



a) What is the net torque acting on the wheel?

$$\sum \tau = F_1 r_1 - F_2 r_2 = 10(0.5) - 6(0.25) = 3.5\ \mathrm{N \cdot m}$$

Answer: $\tau_{net} = 3.5\ \mathrm{N \cdot m}$

b) What is the angular acceleration of the wheel?

$$\sum \tau = I\alpha \quad \Rightarrow \alpha = \frac{\sum \tau}{I} = \frac{3.5}{0.5} = 7\ \mathrm{rad/s^2}$$

Answer: $\alpha = 7\ \mathrm{rad/s^2}$

c) Calculate the tangential acceleration of a point at a distance r_1 from the center of the wheel.

$$a_t = r_1 \alpha = 0.5(7) = 3.5\ \mathrm{m/s^2}$$

Answer: $a_t = 3.5\ \mathrm{m/s^2}$

d) If the wheel starts from rest, how many revolutions does it make in 16 s.

$$\Delta\theta = \omega_i t + \frac{1}{2}\alpha t^2 = 0 + \frac{1}{2}(7)(16)^2 = 896\ rad$$

$$No.of\ revolutions = \frac{\Delta\theta}{2\pi} = 142.7\ revolutions$$

Answer: 142.7 $revolutions$