Kuwait University **Physics Department**

Physics 101

Summer Semester

Final Exam

Monday, July 29, 2019

11:00 am – 01:00 pm

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

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

Choose your Instructor's Name:

Prof. Yacoub Makdisi
Dr. Ahmed Al-Jassar
Dr. Hala Al-Jassar
Dr. Tareq Al Refai
Dr. Belal Salameh

For Instructors use only

Grade:

#	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

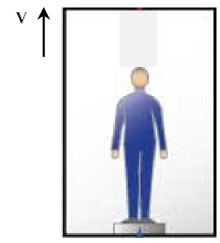
Important:

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/s².
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

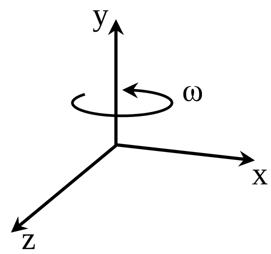
Part I: Questions (Choose the correct answer, one point each)

Q1. A man of mass **m** is inside an elevator that is moving upward with constant speed. **Which of the following statements is correct about the normal force N on the man?**



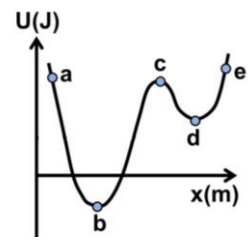
* The work of N is zero
(*) The work of N is positive
* The work of N is negative
* $N < mg$

Q2. In the figure, if the angular speed ω is **decreasing**, then **the direction of the angular acceleration (α) is**



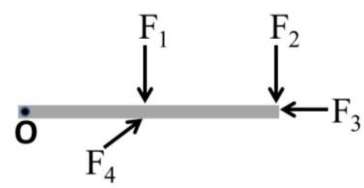
* $+\hat{j}$
(*) $-\hat{j}$
* $+\hat{k}$
* $-\hat{k}$

Q3. A single **conservative force** is exerted on a particle which is moving along the x-axis. The potential energy U of this particle as a function of the position (x) is shown in the figure. **The acceleration of the particle is zero at the points:**



* **c only**
(*) **b, c and d**
* **b and d only**
* **a and e**

Q4. Four forces have the same magnitude ($F_1 = F_2 = F_3 = F_4$) act on a rod which is free to rotate about point **O** as shown in the figure. If the torques exerted on the rod by the four forces are $\boldsymbol{\tau_1}, \boldsymbol{\tau_2}, \boldsymbol{\tau_3}, \boldsymbol{\tau_4}$ then:



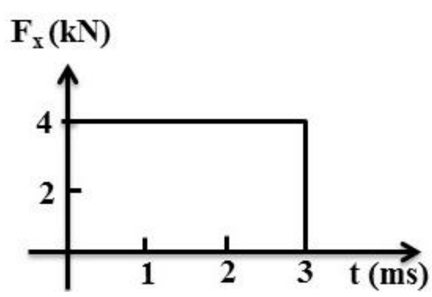
* $\boldsymbol{\tau_1 > \tau_2 > \tau_3 > \tau_4}$
(*) $\boldsymbol{\tau_2 > \tau_1 > \tau_4 > \tau_3}$
* $\boldsymbol{\tau_2 > \tau_3 > \tau_1 > \tau_4}$
* $\boldsymbol{\tau_1 > \tau_4 > \tau_2 > \tau_3}$

Part II: Short Problems (3 points each)

SP1. A 2 kg box **rests** on a frictionless horizontal surface is struck by a ball which is moving along the x-axis. The magnitude of **the net force** exerted on the box during the collision varies with time as shown in the figure. **Find the speed (in m/s) of the box just after the collision.**

$$\Delta p = m(v_f - v_i) = \text{Area} = (4)(3) = 12\ \text{N}\cdot\text{s}$$

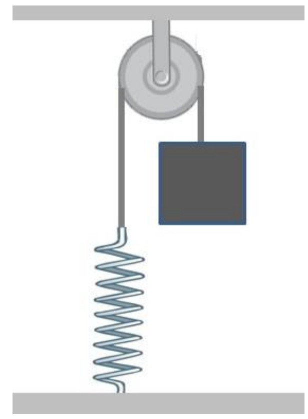
$$v_f = \frac{\Delta p}{m} + v_i = \frac{12}{2} + 0 = 6\ \text{m/s}$$



Answer: $v_f = 6\ \text{m/s}$

SP2. A block of mass 8 kg is fastened to a spring by a light rope that passes over **a massless frictionless pulley** as shown. After the block is released it came to equilibrium after stretching the spring a distance of 0.5 m, **find the force constant of the spring (in N/m).**

$mg = T \ , \ T = kx$

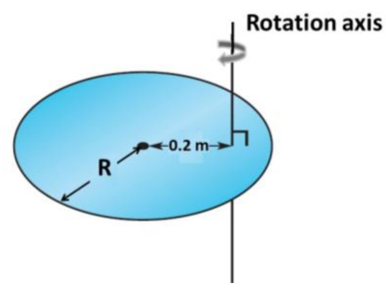


$mg = kx \implies k = \frac{mg}{x}$

$= \frac{80}{0.5} = 160 \, N/m$

Answer: $k = 160 \, N/m$

SP3. A disk (M = 3 kg, R = 0.3 m, $I_{cm} = \frac{1}{2}MR^2$) is rotating about an axis at a radial distance of 0.2 m from its center and perpendicular to the disk as shown in the figure. **If the disk rotates with angular speed of 20 rad/s find its kinetic energy (in J).**



$$I_p = I_{cm} + Md^2 = \frac{1}{2}MR^2 + Md^2 = \frac{1}{2}(3)(0.3)^2 + (3)(0.2)^2$$

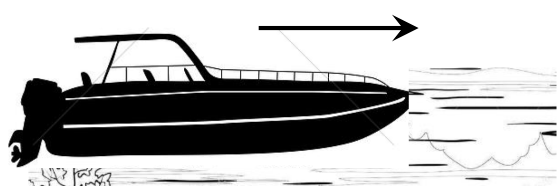
$$= 0.255 \, kg \cdot m^2$$

$$K = \frac{1}{2}I\omega^2 = 51 \, J$$

Answer: $K = 51 \, J$

SP4. The engine of the boat provides a power of 250 hp, giving the boat a forward velocity of 20 m/s. **Find the horizontal force (in N) acting on the boat by its engine. (1 hp = 746 watts)**

Ignore all friction forces.



$P = 250\,(746)W$

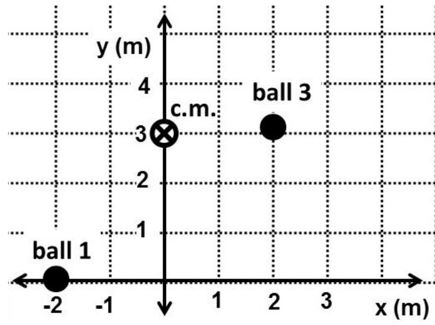
$= 186500 \ W$

$P = \vec{F} \cdot \vec{V} = FV$

$F = \frac{P}{V} = \frac{186500}{20} = 9325 \ N$

Answer: $F = 9325 \ N$

SP5. A system of three small balls (m_1 = 4 kg, m_2 = 2 kg, and m_3) are located in the xy plane. The positions of ball 1, ball 3 and the center of mass of the three balls are shown in the figure. **Ball 2 is located on the y-axis. Find m_3 (in kg).**



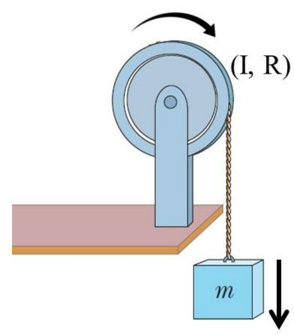
$$x_{cm} = \frac{m_1 x_1 + m_2 x_2 + m_3 x_3}{m_1 + m_2 + m_3} = 0$$

$$0 = \frac{4(-2)+2(0)+m_3(2)}{4+2+m_3}$$

$$2m_3 = 8 \implies m_3 = 4\,kg$$

Answer: $m_3 = 4\,kg$

SP6. A light cable is wrapped around a solid cylinder of radius 0.2 m which is free to rotate about a fixed horizontal axis. A 4 kg block is connected to the free end of the cable as shown in the figure. **The block starts from rest** and reaches a speed of 3 m/s when it falls 2 m. **Find the moment of inertia of the pulley (in kg · m^2).**



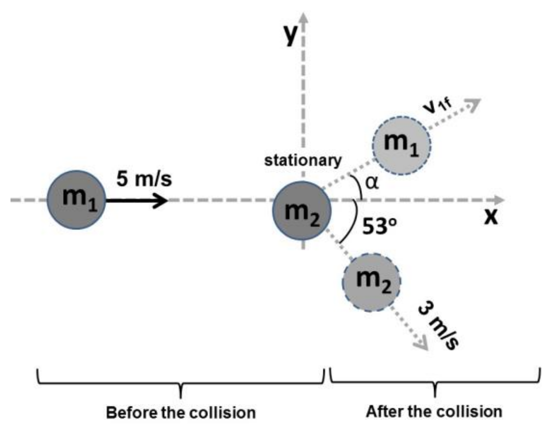
$$E_i = E_f$$

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

$$I = 2\,\frac{R^2}{V_f^2}\left(mgh - \frac{1}{2}mV_f^2\right) = \frac{2(0.2)^2}{(3)^2}\left[4(10)(2) - \frac{1}{2}(4)(3)^2\right] = 0.55\,kg.m^2$$

Answer: $I = 0.55\,kg.m^2$

SP7. Two balls **of equal masses** collides **elastically** on a frictionless table. The velocities of the balls before and after the collision are shown in the figure. **Find the speed (in m/s) of ball 1 after the collision and find the angle α.**



$$\frac{1}{2}\,V_{1i}^2 + 0 = \frac{1}{2}\,V_{1f}^2 + \frac{1}{2}\,V_{2f}^2$$

$$V_{1f} = \sqrt{V_{1i}^2 - V_{2i}^2} = \sqrt{5^2 - 3^2} = 4\,m/s$$

$$\Sigma P_{y1} = \Sigma P_{yf}$$

$$0 = m\,V_{1f}\,\sin\alpha - m\,V_{2f}\,\sin 53$$

$$\alpha = sin^{-1}\left(\frac{V_{2f}\sin 53}{V_{1f}}\right)$$

$$= sin^{-1}\left(\frac{3\sin 53}{4}\right) = 37^\circ$$

[OR]

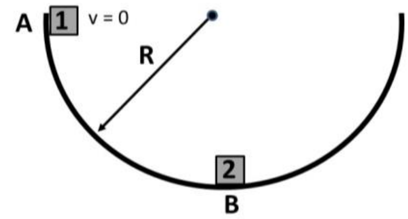
$$\alpha + 53 = 90 \implies \alpha = 37^\circ$$

Answer: $V_{1f} = 4\,m/s$

Answer: $\alpha = 37^\circ$

Part III: Long Problems (5 points each)

LP1. Block 1 (m_1= 2 kg) starts **from rest** at point A and slides down a frictionless bowl of radius R = 0.8 m. It collides with block 2 (m_2= 3 kg) at point B and the **two blocks stick together** after the collision.



a) Find the speed (in m/s) of block 1 just before the collision.

$$m_1 gR = \frac{1}{2} m_1 V_{1B}^2$$

$$V_{1B} = \sqrt{2gR} = \sqrt{2(10)(0.8)} = 4\ m/s$$

Answer: $V_{1B} = 4\ m/s$

b) Find the speed (in m/s) of the composite $(m_A + m_B)$ just after the collision.

$$m_1 V_{1B} = (m_1 + m_2)V_f$$

$$2\,(4) = 5\,V_f$$

$$V_f = 1.6\ m/s$$

Answer: $V_f = 1.6\ m/s$

c) Find the normal force (in N) acting on the composite just after the collision.

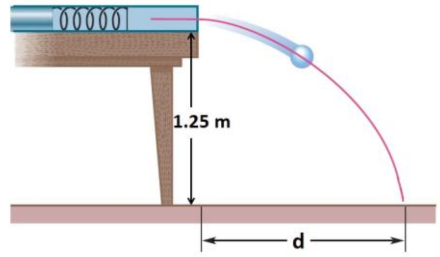
$$n - (m_1 + m_2)g = (m_1 + m_2)\frac{V^2}{R}$$

$$n = (m_1 + m_2)\left[g + \frac{V^2}{R}\right] = 5\left((10) + \frac{(1.6)^2}{0.8}\right) = 66\ N$$

Answer: $n = 66\ N$

LP2. A small ball of mass 72 g is fired from a spring-loaded gun (k = 20 N/m) that is mounted on a table. The spring was compresses a distance of 30 cm and then the ball is fired. **The ball leaves the spring when it is at the edge of the table** as shown. The ball hits the ground at a horizontal distance of **d** from the edge of the table.

Ignore all friction forces



a) **Find the speed (in m/s) of the ball when it leaves the spring.**

$$\frac{1}{2}kx^2 = \frac{1}{2}mv^2$$

$$V = \sqrt{\frac{k}{m}x^2} = \sqrt{\frac{20}{0.072}}\ (0.3)^2 = 5\ m/s$$

Answer: $V = 5\ m/s$

b) **Find the distance d (in m).**

$$\Delta y = V_{yi}\,t - \frac{1}{2}gt^2$$

$$-1.25 = 0 - 5\,(t)^2$$

$$t = 0.5\ s$$

$$d = \Delta x = V_{xi}\,t = 5(0.5) = 2.5\ m$$

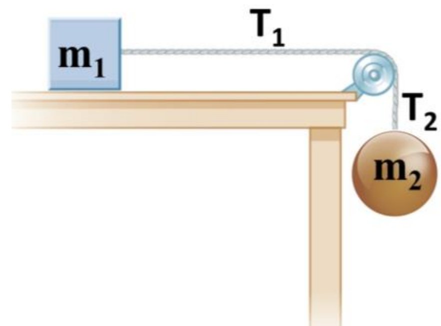
Answer: $d = 2.5\ m$

c) **Find the work (in J) done by gravity on the ball during its motion.**

$$w_{mg} = mgh = 0.072\ (10)(1.25) = +0.9\ \ J$$

Answer: $w_{mg} = +0.9\ \ J$

LP3. A block of mass **m_1 = 5 kg** rests on **a rough** horizontal surface (μ_k = 0.3) is attached to a ball of mass **m_2 = 8 kg** by a light rope that passes over a pulley **of radius R = 0.2 m** as shown in the figure. **When the ball is released it accelerates downward at 1.5 m/s^2.**



a) Find the tensions T_1 and T_2 (in N) in the rope.

$$m_2 g - T_2 = m_2 a$$

$$T_2 = m_2\,(g - a) = 8(10 - 1.5) = 68\ N$$

$$T_1 - \mu_k m_1 g = m_1 a$$

$$T_1 = m_1(\mu_k g + a) = 5(3 + 1.5) = 22.5\ \ N$$

Answer: $T_1 = 22.5\ N$

Answer: $T_2 = 68\ N$

b) Find the net torque (in N.m) exerted on the pulley.

$$\Sigma\tau = T_2 R - T_1 R = (T_2 - T_1)\,R = \ (68 - 22.5)\ 0.2 = 9.1\ N.m$$

Answer: $\Sigma\tau = 9.1\ N.m$

c) Find the moment of inertia (in kg·m^2) of the pulley.

$$\Sigma\tau = I\alpha = I\left(\frac{a}{R}\right)$$

$$\Rightarrow I = \left(\frac{R}{a}\right)(\Sigma\tau) = \frac{0.2}{1.5}\,(9.1) = 1.2\ \ kg.m^2$$

Answer: $I = 1.2\ \ kg.m^2$