Kuwait University **Physics Department**

Physics 101

Spring Semester
Final Exam
Sunday, May 13, 2018
2:00 pm – 4:00 pm

Student's Name: ………………..………………….……………… [illegible]al Number: ….…………

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

Choose your Instructor's Name:

Dr. Ahmed Al-Jassar	Dr. Abdul Mohsen
Dr. Hala Al-Jassar	Dr. Tareq Al Refai
Dr. Fatema Al Dosa[illegible]	Dr. Abdul Khaleq
Dr. Nasser Demir	Dr. Belal Salameh

For Instructors use only

Grades:

#	Q1	Q2	[illegible]	Q4	SP1	SP2	SP3	SP4	SP5	SP6	SP7	LP1	LP2	LP2	Total
	1	[illegible]	1	1	3	3	3	3	3	3	3	5	5	5	40
[illegible]															

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.**

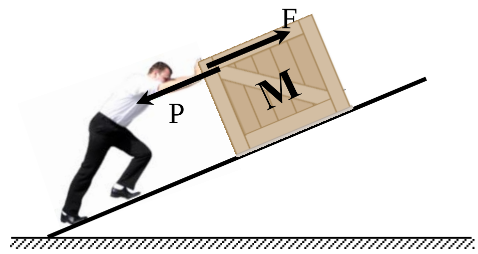
GOOD LUCK

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

Q1. The condition necessary for **the linear momentum to be conserved,** in a given **closed system** is that:

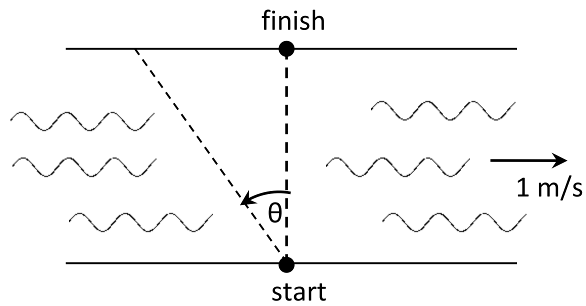
* one body should be at rest
* the net external force is zero
* internal forces equal external forces
* there is a positive change in the kinetic energy

Q2. When a man pushes a box (with a mass M) up **a rough ramp** with a force of magnitude (F), the box is pushing back on **the man's hand** with a force of magnitude (P). **If the man and the box are moving up with a constant acceleration of magnitude** (a), then



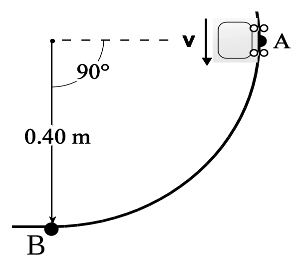
* $F = P$
* $F = P + Ma$
* $F = P + Ma + Mg\sin\theta + f_k$
* $F = P + Ma - Mg\sin\theta - f_k$

Q3. A boy wishes to swim across a river to a point directly opposite as shown. The river is flowing at 1 m/s and the speed of the boy <u>**relative to the water**</u> is 2 m/s. **At what angle (θ) with respect to the line joining the starting and finishing points should he swim?**



* 60°
* 30°
* 63°
* 27°

Q4. A block is released from rest at point A of a circular **frictionless vertical** track as shown. As the block slides down to point B, **the block speed and the magnitude of its tangential acceleration** respectively, are:



* decreasing, decreasing
* increasing, decreasing
* decreasing , increasing
* increasing, increasing

Part II: Short Problems (3 points each)

SP1. At $t = 0$ s, a 4 Kg block has a velocity of $\vec{v} = (4i - 3j)$ m/s . At $t = 3$ s, its velocity is $\vec{v} = (2i + 3j)$ m/s. **Calculate the total work done on the block during this time interval.**

$v_i^2 = 4^2 + 3^2 = 25$

$v_f^2 = 2^2 + 3^2 = 13$

$W_{total} = \Delta K$

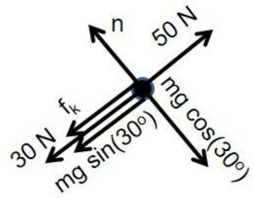
$= \frac{1}{2}\, m v_f^2 - \frac{1}{2}\, m v_i^2$

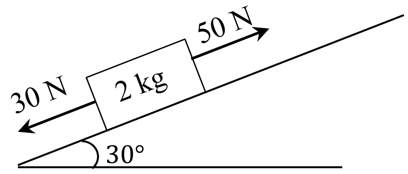
$= 26 \quad - \quad 50$

$= -24$ J

Answer: $W_{total} = -24J$

SP2. A 2 Kg block is pushed across a **rough** incline by two applied forces (50 N and 30 N) as shown. The block moves up the incline with **a constant velocity**. **Find the magnitude of the frictional force on the block**.





$$\Sigma F = ma = 0$$

$$50 - 30 - mg\sin\theta - f_k = 0$$

$$f_k = 20 - 20\sin 30$$

$$= 10\ N$$

Answer: $f_k = 10\ N$

SP3. A wheel ($\mathrm{I} = 0.1\ \mathrm{Kg.m^2}$) starts with initial angular speed of 6 rad/s and rotates through **4 rad** as it is uniformly brought to **rest** by a **constant angular acceleration**. **What is the magnitude of the net torque on the wheel?**

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

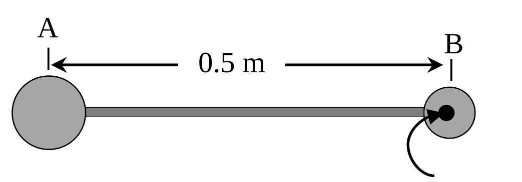
$$0 = 6^2 + 2\,\alpha(4) \Rightarrow \alpha = -4.5\ {}^{rad}/_{s^2}$$

$$|\vec{\tau}| = I\alpha = 0.1\ \times 4.5 = 0.45\ \ N\cdot m$$

Answer: $|\vec{\tau}| = 0.45\ \ N \cdot m$

SP4. Two small masses, $\mathrm{m_A} = 0.2$ Kg and $\mathrm{m_B} = 0.1$ Kg, are connected by a 0.5 m rod of mass M= 0.3 kg as shown. **Calculate the moment of inertia of the system about an axis through the center of B.**

Hint: the moment of inertia of the rod about its center of mass is: $\mathbf{I_{cm}} = \frac{1}{12}\mathbf{ML^2}$



$$I = \Sigma\, m_i r_i^2 + I(rod)$$

$$= m_A\,(0.5)^2 + \frac{1}{12}ML^2 + M\left(\frac{L}{2}\right)^2$$

$$= m_A\,(0.5)^2 + \frac{1}{3}ML^2$$

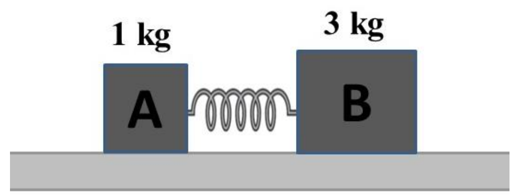
$$= 0.2\,(0.5)^2 + \frac{1}{3}(0.3)(0.5)^2$$

$$= 0.075\ \mathrm{kg\cdot m^2}$$

Answer: I= 0.075 $\mathrm{kg \cdot m^2}$

SP5. Two blocks are placed on **a frictionless horizontal** surface. They forced together, compressing a spring between them; **then the blocks are released from rest** as shown. After the spring is relaxed, block A moves to the left with a speed of 6 m/s. **How much potential energy was stored in the spring before the blocks were released?**

Hint: Assume the total mechanical energy is conserved.



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

$$0 = m_A v_A + m_B v_B$$

$$0 = 1(-6) + 3v_B$$

$$v_B = 2\ \frac{m}{s} \quad to\ the\ right$$

$$E_i = E_f$$

$$U_{el} = \frac{1}{2}\ m_A v_A^2 + \frac{1}{2} m_B v_B^2$$

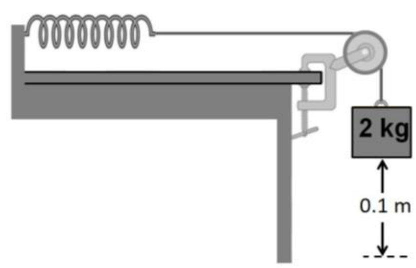
$$U_{el} = \frac{1}{2}\ (1)\ (6)^2 + \frac{1}{2}(3)(2)^2$$

$$U_{el} = 24\ J$$

Answer: $U_{el} = 24\ J$

SP6. A 2 kg box is connected by a light cord that runs over a frictionless pulley (radius R = 0.1 m, and moment of inertia $I = 0.03\ \text{Kg}\cdot\text{m}^2$), to a light spring of spring constant ($k = 120\ \text{N/m}$), as shown. **The box is released from rest when the spring is unstretched.**

What is the speed of the box when it has moved down 0.1 m?



$$E_i = E_f$$

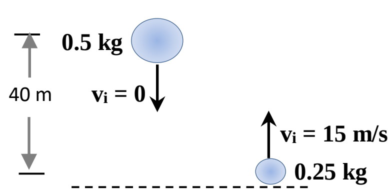
$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}\ I\frac{v^2}{R^2} + \frac{1}{2}kx^2$$

$$v = \sqrt{\frac{mgy - \frac{1}{2}kx^2}{\frac{1}{2}m + \frac{1}{2}\frac{I}{R^2}}}$$

$$v = 0.75\ m/s$$

Answer: $v = 0.75\ m/s$

SP7. At the same instant a 0.5 Kg ball is dropped from 40 m above the ground, a second ball, with a mass of 0.25 Kg, is thrown upward from the ground with an initial speed of 15 m/s. They move along nearby lines without colliding. **What is the magnitude and direction of the velocity of the center of mass of the two-ball system at 2s?**



$$v_{1f} = v_{1i} - gt = 0 - 10(2) = -20\ m/s$$

$$v_{2f} = v_{2i} - gt = 15 - 10(2) = -5\ m/s$$

$$v_{cm} = \frac{m_1 v + m_2 v_2}{m_1 + m_2}$$

$$\frac{0.5\times -20 + 0.25\times -5}{0.5 + 0.25}$$

$= -15\ m/s$ (Downward)

Answer: $v_{cm} = -15\ m/s$ (downward)

Part III: Long Problems (5 points each)

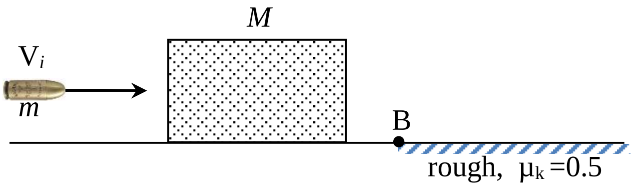
LP1. A bullet of mass m = 0.05 kg is travelling with a speed of $v_i = 80$ m/s when it strikes a block of a mass M = 1.95 kg, which is **at rest** on a smooth part of a horizontal surface as shown. The bullet **embeds itself in the block** and after the impact **they slide together and then enter a rough surface.**

a) What is the speed of the block immediately after the collision?

$$mv_i = (m+M)v_f$$

$$(0.05)(80) = (2)v_f$$

$$v_f = 2\ m/s$$



Answer: $v_f = 2\ m/s$

b) Calculate the change in the kinetic energy of the system (ΔK) as a result of the collision.

$$\Delta k = k_f - k_i = \frac{1}{2}(m+M)v_f^2 - \frac{1}{2}mv_i^2$$

$$\Delta k = \frac{1}{2}(2)(2)^2 - \frac{1}{2}(0.05)(80)^2$$

$$= -156\ J$$

Answer: $\Delta k = -156\,J$

c) If the rough part has a coefficient of kinetic friction of $\mu_k = 0.5$. At what distance from B will the block stop?

$$E_f - E_i = w_{fk}$$

$$0 - \frac{1}{2}m_{tot}v^2 = -\mu_k m_{tot} g d$$

$$d = \frac{\frac{1}{2}v^2}{\mu_k g} = 0.4\ m$$

[or] $a = \frac{\sum F}{m} = \frac{-\mu_k mg}{m} = -\mu_k g = -5\ m/s^2$

$$v_F^2 = v_i^2 + 2ad$$

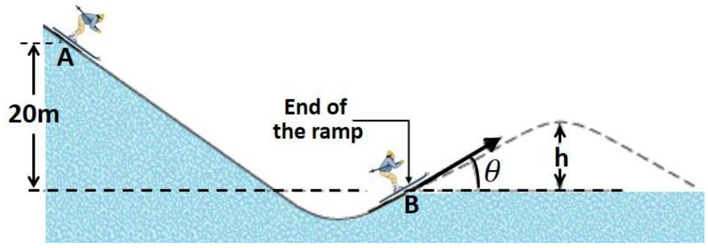
$$d = \frac{v_F^2 - v_i^2}{2a} = \frac{0-(2)^2}{-10}$$

$$= 0.4\ m$$

Answer: $d = 0.4\ m$

LP2: A 60 kg skier starts **from rest at point A** and slides on a frictionless ramp until point B (end of the ramp) and then leaves the ramp at angle $\theta = 30°$, as shown in the figure.

(a) Find the skier's speed at point B.



$E_i = E_f$

$mgy = \frac{1}{2} mv_B^2$

$v_B = \sqrt{2gy} = \sqrt{2(10)(20)} = 20\ m/s$

Answer: $v_B = 20\ m/s$

(b) What is the maximum height ($\boldsymbol{h}$) of his jump?

$v_{yB} = v_B \sin\theta = 20 \sin 30^o = 10\ m/s$

$v_{yf}^2 = v_{yi}^2 - 2gh$

$0 = (10)^2 - 2(10)(h)$

$h = 5\ m$

Answer: $h = 5\ m$

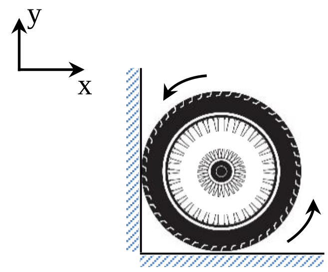
(c) If another skier with mass M = 80 Kg make the same ski jump, the maximum height *h* will be

* greater

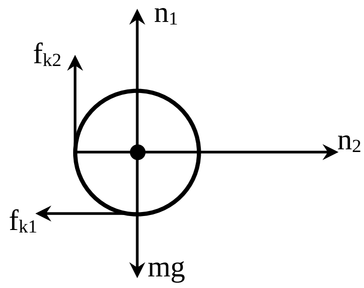
* less

* the same

LP3. A wheel of mass m = 4 Kg, radius R = 0.3 m, and a moment of inertia I = 0.18 kg·m^2 rotates against a horizontal and a vertical surfaces about a fixed axis as shown in the figure. **The coefficient of kinetic friction between the wheel and both surfaces is of μ_k= 0.2.** The initial angular speed of the wheel at the instant it is placed in the corner is **ω_i = 20 rad/s.**



a) Draw a free body diagram for the wheel.



b) If the frictional force between the wheel and the horizontal surface is (f_{k1}) and between the wheel and the vertical surface is (f_{k2}). Find the magnitudes of f_{k1} and f_{k2}.

$\Sigma F = 0$

$n_2 - f_{k1} = 0 \ \Rightarrow n_2 = f_{k1} = \mu_k n_1$ ------1

$n_1 + f_{k2} - mg = 0 \ \Rightarrow n_1 = mg - \mu_k n_2$ -----2

Solve 1 & 2 $\Rightarrow f_{k1} = \frac{\mu_k mg}{1+\mu_k^2} = 7.69\ N$

$n_2 = f_{k1} = 7.69\ N$

$f_{k2} = \mu_k n_2 = 1.54\ N$

Answer: $f_{k1} = 7.69\ N$

Answer: $f_{k2} = 1.54\ N$

c) Find the magnitude of the angular acceleration of the wheel?

$\Sigma\tau = I\alpha$

$-R\, f_{k1} - R f_{k2} = I\alpha$

$\alpha = \frac{-R(f_{k1}+f_{k2})}{I} = \frac{-0.3(7.7+1.54)}{0.18} = -15.4\ \frac{rad}{s^2}$

$|\alpha| = 15.4\ \frac{rad}{s^2}$

Answer: $|\alpha| = 15.4\ \frac{rd}{s^2}$