Kuwait University **Physics Department**

Physics 101

Summer Semester

Final Exam

Monday, August 15, 2022

2:00 PM – 4:00 PM

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

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

Choose your Instructor's Name:

Dr. Fatema Aldossari Dr. Belal Salameh

Dr. Abdul Khaleq

For Instructors use only

Grades:

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

Important:

1. Answer all questions and problems (No solution = no points).
2. Full mark = 40 points as arranged in the above table.
3. **Give your final answer in the correct unit.**
4. Assume $g = 10\ m/s^2$.
5. Mobiles are **strictly prohibited** during the exam.
6. Programmable calculators, which can store equations, are not allowed.
7. **Cheating incidents will be processed according to the university rules.**

GOOD LUCK

Part I: Short Problems (3 points each)

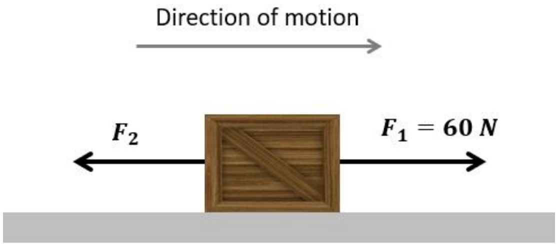
SP1. A 4 Kg block is pushed across a **rough** horizontal surface ($\boldsymbol{\mu_k = 0.4}$) by two applied forces, as shown. The block moves **to the right** with acceleration of 2 m/s^2. **Find the magnitude of the force $\boldsymbol{F_2}$.**

$$\Sigma F = ma$$

$$F_1 - F_2 - \mu_k mg = ma$$

$$F_2 = F_1 - \mu_k mg - ma$$

$$= 60 - (0.4)(40) - (4)(2) = 36\ N$$



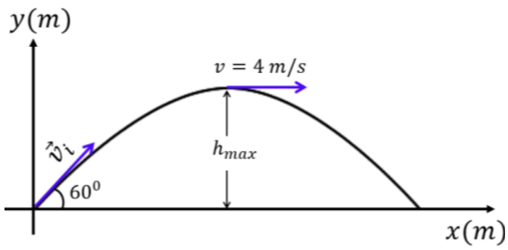
SP2. A stone is projected from the ground level, as shown. **If the speed of the stone at the maximum height is 4 m/s, find the maximum height ($\boldsymbol{h_{max}}$) of the stone.**

$$v_{xi} = v_i \cos\theta \Rightarrow v_i = \frac{v_{xi}}{\cos\theta} = \frac{4}{\cos 60^o} = 8\ m/s$$

$$v_{y_f}^2 = v_{y_i}^2 - 2g\Delta y$$

$$0 = (v_i \sin 60^o)^2 - 20h_{max}$$

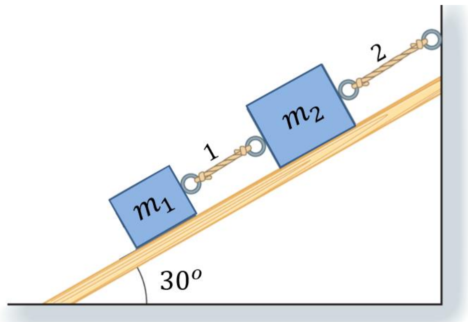
$$\Rightarrow h_{max} = \frac{(8\sin 60^o)^2}{20} = 2.4\ m$$



SP3. Two blocks ($m_1 = 8\ kg, m_2 = 12\ kg$) **rest on a frictionless incline** are connected by a string and tied to a wall by another string, as shown. **Find the tension in each string ($\boldsymbol{T_1}$ and $\boldsymbol{T_2}$).**

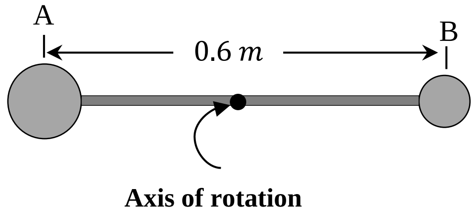
$$T_1 = m_1 g \sin 30^0 = 40\ N$$

$$T_2 = (m_1 + m_2) g \sin 30^0 = 100\ N$$



SP4. Two small masses, $m_A = 0.3$ Kg and $m_B = 0.2$ Kg, are connected by a rod ($L_{rod} = 0.6\,m,\ M_{rod} = 0.4\,kg$), as shown. The system rotates about **a vertical axis that passes through the center of the rod** with angular speed $\omega = 40\,rad/s$. **Find the rotational kinetic energy of the system.**

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



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

$$= m_A\,(0.3)^2 + m_B\,(0.3)^2 + \frac{1}{12}ML^2$$

$$= 0.3\,(0.3)^2 + 0.2\,(0.3)^2 + \frac{1}{12}(0.4)(0.6)^2 = 0.057\ \text{kg}\cdot\text{m}^2$$

$$K_{rot} = \frac{1}{2}I\omega^2 = \frac{1}{2}(0.057)(40^2) = 45.6\,J$$

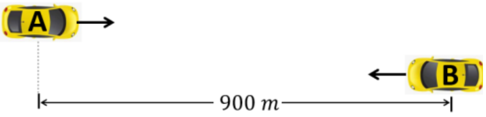
SP5. A fan is rotating at $12\,rad/s$. When turned off, it slows **uniformly** and stops in 60 s. **How many revolutions does the fan make during this time?**

$$\alpha = \frac{\omega_f - \omega_i}{t} = \frac{0 - 12}{60} = -0.2\,rad/s^2$$

$$\Delta\theta = \omega_i t + \frac{1}{2}\alpha t^2 = 12(60) + \frac{1}{2}(-0.2)(60^2) = 360\,rad$$

$$number\ of\ revolutions = \frac{360}{2(3.14)}rev = 57.3\,rev$$

SP6. Car A is moving due east with **a constant speed** of 20 m/s. Car B starts moving **from rest** when the distance between the two cars is 900 m to the west with **a constant acceleration** of 2 m/s^2, as shown. **Find the time before the two cars pass each other?**



$v_A = 20\, m/s \qquad a_B = 2\, m/s^2 \qquad v_{B_i} = 0$

$$900 = \Delta x_A + \Delta x_B$$

$$= v_A t + \frac{1}{2} a_B\, t^2$$

$$900 = 20t + t^2$$

$$t^2 + 20t - 900 = 0$$

$$t = \frac{-20 \pm \sqrt{400 - 4(-900)}}{2} = 21.6\, s$$

SP7. A ball ($m = 0.5\, kg$) **rests** on the ground. A boy kicked the ball by his foot and the average force exerted on the ball during the kick is 270 N. If the ball's speed immediately after the kick is 5.4 m/s. **Find the contact time between the foot and the ball.**

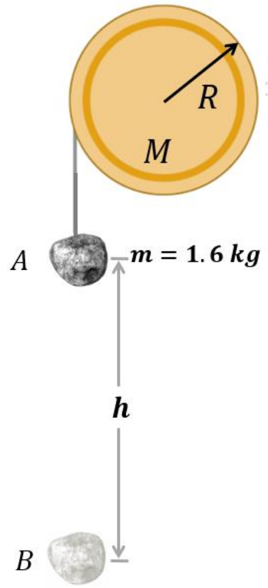
$$|\Delta\vec{p}| = \left(\sum F\right)_{av} \Delta t$$

$$m(v_f - v_i) = \left(\sum F\right)_{av} \Delta t$$

$$0.5(5.4 - 0) = 270\, \Delta t \;\Rightarrow \Delta t = 0.01\, s$$

Part II: Long Problems (5 points each)

LP1. A 1.6 kg stone is attached to a light wire that is wrapped around the rim of a uniform solid disk ($M = 2\ kg, R = 10\ cm, I = \frac{1}{2}MR^2$), as shown. The stone is released **from rest at point A**. The rotational kinetic energy of the disk when the stone reaches point B is 8 J



a) Find the speed of the stone when it reaches point B.

$$K_{rot} = \frac{1}{2}I\omega^2 = \frac{1}{2}\left(\frac{1}{2}MR^2\right)\left(\frac{v}{R}\right)^2 = \frac{1}{4}Mv^2$$

$$v = \sqrt{\frac{4K_{rot}}{M}} = \sqrt{\frac{4(8)}{2}} = 4\ m/s$$

b) Find the height h.

$$E_i \quad = \quad E_f$$

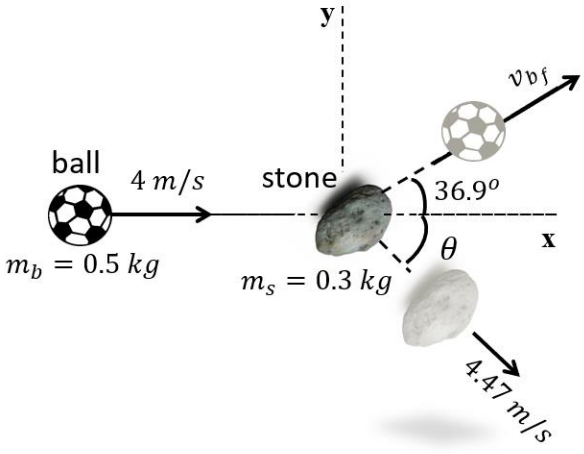
$$mgh = K_{rot} + \frac{1}{2}mv^2$$

$$h = \frac{K_{rot} + \frac{1}{2}mv^2}{mg} = \frac{8 + \frac{1}{2}(1.6)(4^2)}{16} = 1.3\ m$$

c) Find the change in the gravitational potential energy of the system when the stone moves from point A to point B.

$$\Delta U_g = U_g(B) - U_g(A) = 0 - mgh = -(1.6)(10)(1.3) = -20.3\ J$$

LP2. A ball $(m_b = 0.5\ kg)$ **traveling along the x-axis at** $\boldsymbol{4\ m/s}$ collides **elastically** with a stone $(m_s = 0.3\ kg)$ that **rests** on a frictionless horizontal surface. After the collision, the ball and the stone move as shown in the figure.



a) Find the speed of the ball after the collision ($\boldsymbol{v_{b_f}}$).

$$\sum K_i \quad = \quad \sum K_f$$

$$\frac{1}{2}m_b v_{b_i}^2 + 0 = \frac{1}{2}m_b v_{b_f}^2 + \frac{1}{2}m_s v_{s_f}^2$$

$$0.5(4^2) = +0.5\ v_{b_f}^2 + 0.3(4.47^2)$$

$$v_{b_f} = 2\ m/s$$

b) Find the angle $\boldsymbol{\theta}$.

$$\sum p_{x_i} \quad = \quad \sum p_{x_f}$$

$$m_b v_{b_i} + 0 = m_b v_{b_f}\ \cos 36.9^o + m_s v_{s_f} \cos\theta$$

$$0.5(4) = 0.5(2)(0.8) + 0.3(4.47)\cos\theta$$

$$\theta = 26.5^o$$

OR

$$\sum p_{y_i} \quad = \quad \sum p_{y_f}$$

$$0 = m_b v_{b_f}\ \sin 36.9^o - m_s v_{s_f} \sin\theta$$

$$\theta = \sin^{-1}\left(\frac{m_b v_{b_f}\ \sin 36.9^o}{m_s v_{s_f}}\right) = \sin^{-1}\left(\frac{0.5(2)(.6)}{0.3(4.47)}\right) = 26.5^o$$

c) Find the momentum of the system after the collision in unit vector notation.

$$\sum \vec{p}_i \quad = \quad \sum \vec{p}_f = m_b \vec{v}_{b_i} + 0 = 0.5\ (4\hat{\imath}) = 2\ \hat{\imath}\ \ kg \cdot m/s$$

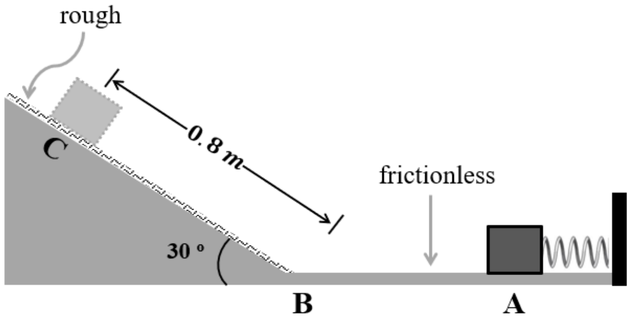
OR

$$\sum \vec{p}_f = m_b \vec{v}_{b_f} + m_s \vec{v}_{s_f}$$

$$= 0.5[2\cos\ 36.9^o\hat{\imath} + 2\sin\ 36.9^o\hat{\jmath})] + 0.3[4.47\ cos26.5^o\hat{\imath} - 4.47\sin 26.5^o\hat{\jmath}] = 2\ \hat{\imath}\ \ kg \cdot m/s$$

LP3. A 1.2 kg block initially compresses a spring a distance $x = 0.2\,m$ before being released **from rest** at point A. The block then slides along **a frictionless** horizontal surface until point B, **then on a rough incline ($\boldsymbol{\mu_k = 0.5}$) between point B and point C**. **The block stops momentarily at point C.**

a) Find the speed of the block at point B.



From B to C

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

$$mgy_C - \frac{1}{2}mv_B^2 = -\mu_k mg\,cos(30^o)d$$

$$v_B = \sqrt{2gy_C + 2g\,\mu_k\,d\,cos(30^o)} = \sqrt{2g(0.8\sin(30^o)) + 2g(0.5)(0.8)\,cos(30^o)} = 3.86\,m/s$$

b) Find the force constant of the spring.

From A to B

$$E_A = E_B$$

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

$$k = m\frac{v_B^2}{x_A^2} = 1.2\left(\frac{3.86^2}{0.2^2}\right) = 448\,N/m$$

c) Find the total work done on the block between point B and point C.

From B to C

$$\sum w = \Delta K = K_C - K_B = 0 - \frac{1}{2}mv_B^2 = -\frac{1}{2}(1.2)(3.86^{\,2}) = -8.9\,J$$

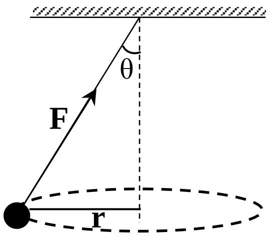
OR

$$\sum w = w_{mg} + w_{f_k} = -mg(0.8\sin 30^o) - \mu_k mg\cos 30^o\,(0.8)$$

$$= -12(0.8\sin 30^o) - 0.5(12)\cos 30^o\,(0.8) = -8.9\,J$$

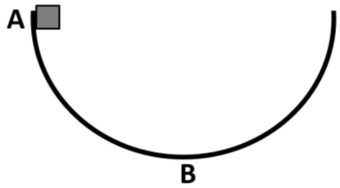
Part III: Questions (Choose the correct answer, one point each)

Q1. The ball of a conical pendulum is rotating in **a horizontal plane with constant speed,** as shown. **The work done on the ball by gravity during one complete revolution equals**



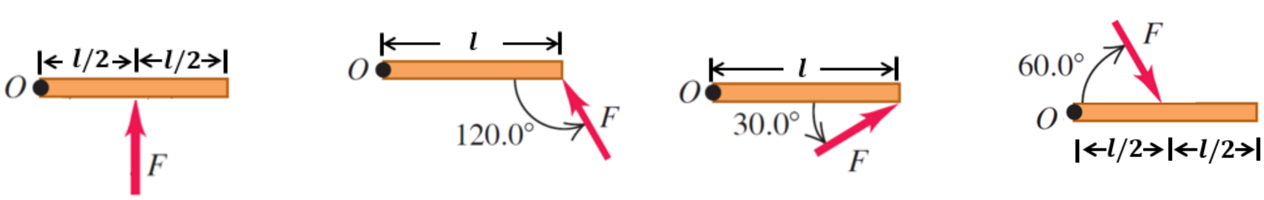
* $F(2\pi r \sin\theta)$
* $F(2\pi r \cos\theta)$
* $F(2\pi r \tan\theta)$
* zero

Q2. A block is released **from rest at point A** and slides inside **a frictionless** hemispherical track, as shown. **The normal force (n) exerted by the track on the block as the block moves from point A to point B**



* increases
* decreases
* remains constant

Q3. In each figure, the force F acts on a rod of length L that is free to rotate about an axis through point O, as shown. Both the force F and the rod lie in the xy-plane. **The magnitude of the torque about point O is maximum in**



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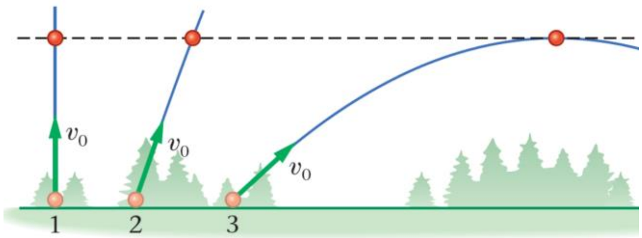
Q4. Three balls with different masses are thrown with the **same initial speed v_o,** but at different angles relative to the horizontal, as shown. Ignoring air resistance, **which of the following statements is correct at the dashed level**



* ball 3 has the lowest speed
* ball 1 has the lowest speed
* all three balls have the same speed
* the speed of each ball depends on its mass.