Kuwait University Physics Department

Physics 101

Summer Semester

Final Exam

Monday, September 20, 2021

11:00 AM – 01:00 PM

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

Student's Number: ….…… Section: ……

Choose your Instructor's Name:

Dr. Hala Al-Jassar
Dr. Fatema Al Dosari
Dr. Tareq Al Refai
Dr. Abdul Khaleq
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

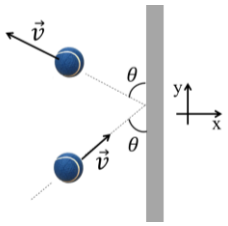
Important:

1. Answer all questions and problems (No solution = no points).
2. Full mark = 40 points as arranged in the above table.
3. **Give your final answer in the correct units.**
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

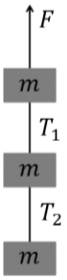
Part I: Questions (Choose the correct answer, one point each)

Q1. A ball of mass m strikes a vertical wall with initial speed $\boldsymbol{v}$ and rebounds with **the same speed $\boldsymbol{v}$** as shown. **The impulse given to the ball by the wall is:**



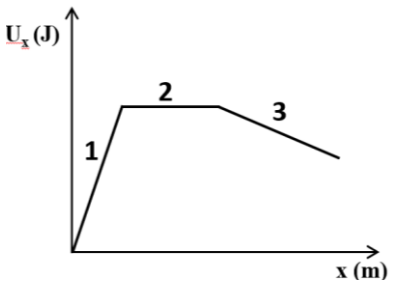
* $-2mv\,\hat{\imath}$ * $2mv\,sin\,\theta\,\hat{\imath}$ (*) $-2mv\,sin\,\theta\,\hat{\imath}$ * $-2mv\,cos\,\theta\,\hat{\imath}$

Q2: Three identical blocks connected by very light cords are given an **upward acceleration** by a constant force F, as shown. T_1 and T_2 are the tensions in the connecting cords. **Which of the following is correct?**



* $T_1 < T_2$ * $T_1 = T_2$ (*) $T_1 > T_2$ * $F < T_1$

Q3. a particle moves along the x-axis under the influence of a single **conservative force**. The potential energy of the system as a function of position is shown. **Rank the labeled regions according to the magnitude of the net force acting on the particle, smallest to largest.**

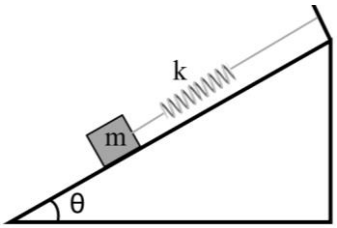


* 1, 3, 2 (*) 2, 3, 1 * 3, 2, 1 * 1, 2, 3

Q4. In the figure, the inclined plane is **smooth.** If the extension in the spring is x at the **equilibrium** position (acceleration $\boldsymbol{a} = \boldsymbol{0}$), then the **spring constant** ($\boldsymbol{k}$) **is**:

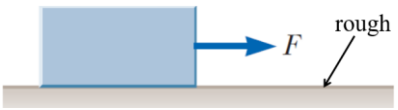
(*) $k = \frac{mgsin\theta}{x}$ * $k = \frac{mgcos\theta}{x}$

* $k = \frac{mgtan\theta}{x}$ * $k = \frac{mg}{x}$



Part II: Short Problems (3 points each)

SP1: A 20 kg block moves on **a rough** horizontal surface ($\mu_k = 0.4$) under the influence of a constant horizontal force $F = 120\ N$ as shown. **Find the acceleration of the block.**

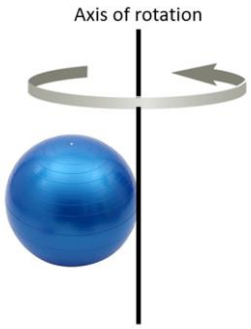


$120 - \mu_k mg = ma$

$$\Rightarrow a = \frac{120 - \mu_k mg}{m} = \frac{120 - (0.4)(200)}{20} = 2\ m/s^2$$

Answer: $a = 2\ m/s^2$

SP2: A uniform solid sphere ($R = 0.5\,m$, $M = 4\,kg$, $I_{cm} = \frac{2}{5}MR^2$) rotates about an axis that is tangent to its surface with constant angular speed $\omega = 6\,rad/s$, as shown. **Find the rotational kinetic energy of the sphere.**

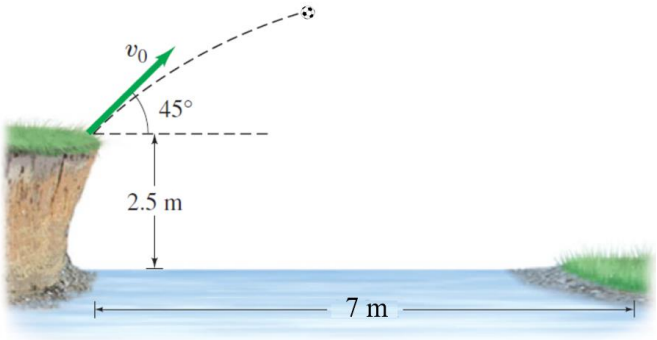


$$I = I_{cm} + MR^2 = \frac{2}{5}MR^2 + MR^2 = \frac{7}{5}MR^2$$

$$K = \frac{1}{2}I\omega^2 = \frac{7}{10}MR^2\omega^2 = \frac{7}{10}(4)(0.5^2)(6^2) = 25.2\,J$$

Answer: $K = 25.2\,J$

SP3: A ball is projected from the top of a cliff at 45° above the horizontal and lands 7 m away as shown. **What is the initial speed of the ball?**



$$\Delta x = v_{x_i}t = v_i\cos 45^o\,(t) \Rightarrow t = \frac{7}{v_i\cos 45^o}$$

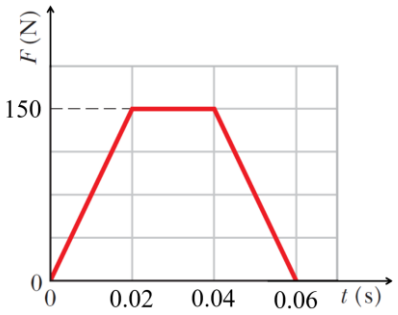
$$\Delta y = v_{y_i}t - \frac{1}{2}gt^2$$

$$-2.5 = v_i\sin 45^o\left(\frac{7}{v_i\cos 45^o}\right) - 5(\frac{7}{v_i\cos 45^o})^2$$

$$-9.5 = \frac{-245}{v_i^2\cos^2 45^o} \Rightarrow v_i = 7.2\,m/s$$

Answer: $v_i = 7.2\,m/s$

SP4: A 0.1 kg ball collides with a wall. The figure shows a plot of the force ***F*** exerted on the ball during the collision versus time ***t***. The ball is given initial speed ***v*** **perpendicular to the wall and rebounds directly back with the same speed in the opposite direction. What is the initial speed of the ball**?



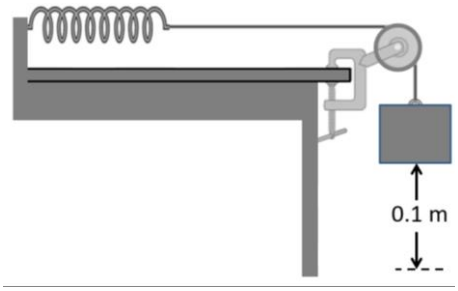
$$Area = \Delta p = mv - m(-v) = 2mv$$

$$0.01(150) + 0.02(150) + 0.01(150) = 6\,kg\,m/s$$

$$2mv = 6 \Rightarrow v = \frac{6}{2m} = 30\,m/s$$

Answer: $v = 30\,m/s$

SP5. A 4 kg box is connected by a light cord that runs over **a frictionless and massless pulley**, to a spring ($k = 200\ N/m$), as shown. **The box is released from rest when the spring is unstretched, find the speed of the box when it moves 0.1 m down.**



$$E_i = E_f$$

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

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

$$v = 1.2\ m/s$$

Answer: $v = 1.2\ m/s$

SP6: A child sits in a boat and the boat rests on water. The boy throws a 5 kg package out horizontally with a speed of 6 m/s **along the positive x-axis** as shown. **Find the velocity of the boat immediately after throwing the package**. The mass of the child is 20 kg and the mass of the boat is 40 kg.

(ignore friction between the boat and water)

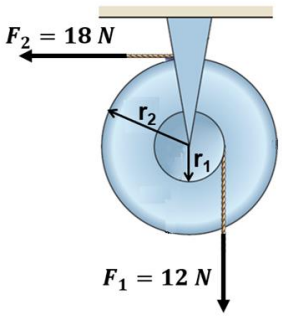
$$m_1\vec{v}_{1_i} + m_2\vec{v}_{2_i} = m_1\vec{v}_{1_f} + m_2\vec{v}_{2_f}$$

$$0 = 5\ (+6\hat{\imath}) + (60)\ \vec{v}_{2_f}$$

$$\vec{v}_{2_f} = \frac{-30\hat{\imath}}{60} = -0.5\ \hat{\imath}\ m/s$$

Answer: $\vec{v}_{2_f} = -0.5\ \hat{\imath}\ m/s$

SP7. Two forces act on a pulley ($I = 0.2\ kg \cdot m^2$) as shown. The forces are applied at radial distances $r_1 = 0.25\ m$ and $r_2 = 0.5\ m$ respectively. **Find the angular acceleration of the pulley.**



$$\sum \tau = I\alpha \Rightarrow F_2R_2 - F_1R_1 = I\alpha$$

$$\Rightarrow \quad \alpha = \frac{F_2R_2 - F_1R_1}{I} = \frac{18(0.5) - 12(0.25)}{0.2} = 30\ rad/s^2$$

Answer: $\alpha = 30\ rad/s^2$

Part III: Long Problems (5 points each)

LP1. A solid disk of radius $0.06\ m$ rotates about its center with **constant angular acceleration**. The angular speed of the disk changes from $2\ rad/s$ at $t = 0\ s$ to $17\ rad/s$ at $t = 3\ s$.

a) Find the magnitude of the angular acceleration of the disk.

$$\omega_f = \omega_i + \alpha t$$
$$17 = 2 + \alpha(3) \implies \alpha = 5\ rad/s^2$$

Answer: $\alpha = 5\ rad/s^2$

b) How many revolutions does the disk make during the first $3\ s$?

$$\Delta\theta = \omega_i t + \frac{1}{2}\alpha t^2$$
$$= 2(3) + \frac{1}{2}(5)(3)^2 = 28.5\ rad$$
$$n = \frac{\Delta\theta}{2\pi} = \frac{28.5}{2(3.14)} = 4.54 \text{ revolutions}$$

Answer: $n = 4.54$ revolutions

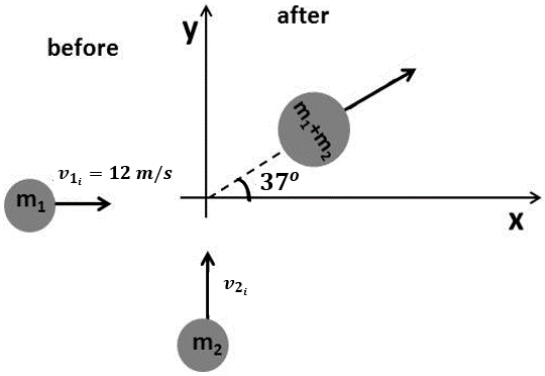
c) Find the magnitude of the radial acceleration of a point at the rim of the disk at $t = 3\ s$.

$$a_R = R\omega^2 = 0.06\ (17)^2 = 17.3\ \ m/s^2$$

Answer: $a_R = 17.3\ \ m/s^2$

LP2. Two balls ($m_1 = 2\ kg$ and $m_2 = 4\ kg$) collide on a horizontal frictionless surface and **stick together** after the collision as shown.

a) What is the speed of the sticked balls after the collision?



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

$$m_1(v_{1i}) + 0 = (m_1 + m_2)\, v_{x_f}$$

$$24 = 6\, v_f \cos 37^o$$

$$v_f = 5\ m/s$$

Answer: $v_f = 5\ m/s$

b) What is the initial speed of m_2?

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

$$0 + m_2\,(v_{2i}) = (m_1 + m_2)\, v_f \sin 37^o$$

$$\Rightarrow v_{2i} = \frac{(m_1+m_2)}{m_2}\, v_f \sin 37^o = 4.5\ m/s$$

Answer: $v_{2i} = 4.5\ m/s$

c) Find the change in the kinetic energy of the system.

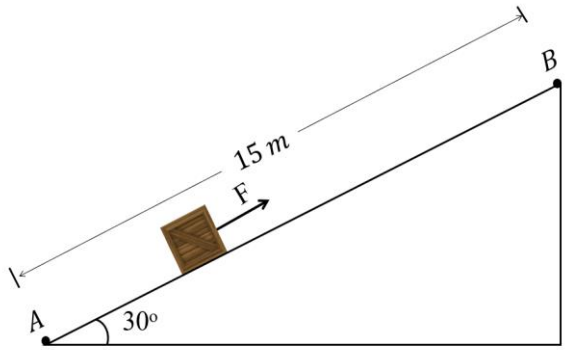
$$\Delta K = \frac{1}{2}(m_1 + m_2)\, v_f^2 - \left(\frac{1}{2} m_1\, v_{1_i}^2 + \frac{1}{2} m_2\, v_{2_i}^2\right)$$

$$= \frac{1}{2}(6)\, 5^2 - \left[\frac{1}{2} 2\,(12)^2 + \frac{1}{2} 4 (4.5)^2\right] = -109.5\ J$$

Answer: $\Delta K = -109.5\ J$

LP3. A 50 kg block is pulled by the force F along **a rough incline** ($\mu_k = 0.5$) as shown. The block moves **with constant speed** from point ***A*** to point ***B*** in 20 $seconds$. The distance between ***A*** and ***B*** is 15 m.

a) Find the work done on the block by the frictional force between points *A* and *B*.



$$W_{f_k} = -f_k d = -\mu_k\, mg\cos\theta\ (d)$$

$$= -0.5\,(50)(10)\cos(30°)(15)$$

$$= -3247.6\,J$$

Answer: $W_{f_k} = -3247.6\,J$

b) Find the work done on the block by the force *F* between points *A* and *B*.

$$\sum W = W_F + W_{f_k} + W_{mg} = \Delta K = 0$$

$$W_F = -\left(W_{f_k} + W_{mg}\right) = -(-3247.6 - mgd\ sin30^o)$$

$$= 3247.6 + 50(10)\sin(30°)(15) = 6997.6\ J$$

Answer: $W_F = 6997.6\ J$

c) Find the average power delivered by the force *F* between points *A* and *B*.

$$P = \frac{W_F}{\Delta t} = \frac{6997.6}{20} = 350\ W$$

Answer: $P = 350\ W$