Kuwait University — Physics Department

جامعة الكويت
KUWAIT UNIVERSITY

Physics 101

Fall Semester

Final Exam

Saturday, December 28, 2024

5:00 pm – 7:00 pm

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

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

Choose your Instructor's Name:

Instructors: Drs. Al Dosari, Al Jassar, Al kurtass, Al Qattan, Al Refai, Al Smadi, Askar, Demir, Salameh, Zaman

For Instructors use only

Grades:

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

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/s².
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 wheel slows down from $\omega_i = 20\,rad/s$ to $\omega_f = 12\,rad/s$ in $5\,s$ under a constant angular acceleration. **Find the angular displacement ($\Delta\theta$), in radians, during these 5 s.**

$$\omega_f = \omega_i + \alpha t$$

$$\alpha = \frac{12-20}{5} = -1.6rad/s^2$$

$$\Delta\theta = \omega_i t + \tfrac{1}{2}\alpha t^2 = 20 \times 5 + 0.5 \times -1.6 \times 25 = 80\,rad$$

OR

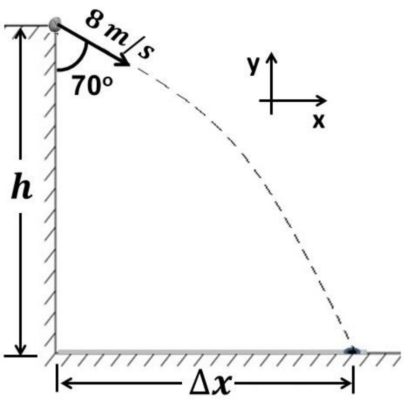
$$\Delta\theta = \left(\frac{\omega_i + \omega_f}{2}\right)\Delta t = \left(\frac{20+12}{2}\right)5 = 80\,rad$$

SP2. A rocket moves along the x-axis. Its position as a function of time is given by $x(t) = 4t - 5t^3$, where t is in seconds and x is in meters. **Find the average acceleration (in m/s^2) between $t = 0\ s$ and $t = 2\ s$.**

$$v = \frac{dx}{dt} = 4 - 15t^2$$

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{v(2)-v(0)}{2-0} = \frac{[4-15(2^2)]-[4-10(0^2)]}{2} = -30\,m/s^2$$

SP3. A ball is projected from a window of a building of height (h). The ball is given an initial speed of $8\,m/s$, as shown. If the horizontal distance $\Delta x = 22.6\,m$, **find the height h (in m).**



$$\Delta x = 22.6\,m = v_0 sin(70°)(t) = 8 \times 0.94 \times t$$

$$t = 3\,s$$

$$\Delta y = -v_0 cos(70°)t - \frac{1}{2}gt^2$$

$$\Delta y = -8.2 - 5(9) = -53.2\,m$$

$$h = 53.2\,m$$

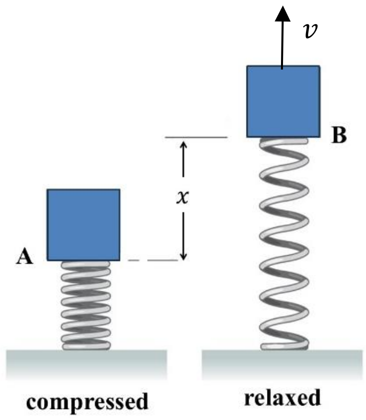
SP4: A 0.4 kg block compresses a spring ($k = 370\ N/m$) a distance $x = 20\ cm$, then the block is **released from rest** at point A. **Find the speed (in m/s) of the block when the spring is relaxed (at point B).**

$E_A = E_B$

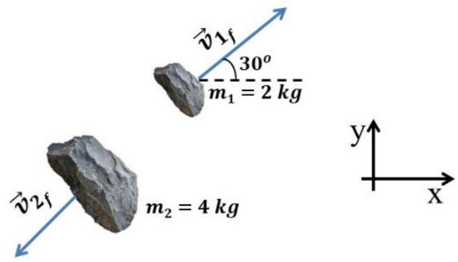
$\frac{1}{2}kx^2 = \frac{1}{2}mv^2 + mgx$

$\frac{1}{2} \times 370 \times 0.2^2 = \frac{1}{2} \times 0.4 \times v^2 + 0.4 \times 10 \times 0.2$

$v = 5.74\ m/s$



SP5. A 6 kg stone **rests** at the origin explodes into two masses $m_1 = 2\ kg$ and $m_2 = 4\ kg$, as shown. After the explosion, m_1 moves with a speed $v_{1f} = 5\ m/s$, 30° north of east. **Find the final velocity of m_2, in unit vector notation**.



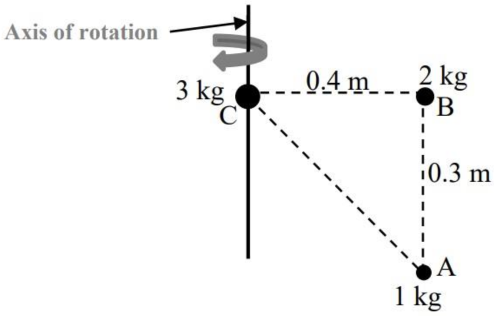
$\sum \vec{p}_i = \sum \vec{p}_f$

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

$0 = 2(5cos30\hat{\imath} + 5sin30\hat{\jmath}) + 4(\vec{v}_{2f})$

$\vec{v}_{2f} = (-2.17\hat{\imath} - 1.25\hat{\jmath})\ m/s$

SP6. A system consists of three small disks rotating about an axis that passes through disk C and parallel to the line connecting B and A as shown. The angular position of the disk B is given by $\theta(t) = -5t + 2t^3$, where t is in seconds and θ is in radians. **Find the rotational kinetic energy (in J) of the system at $t = 2s$.**



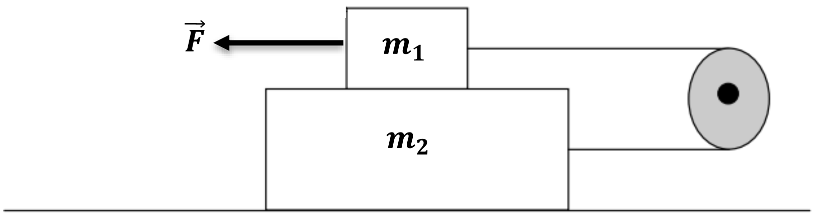
$$I = m_A r_A^2 + m_B r_B^2 = 1 \times 0.4^2 + 2 \times 0.4^2 = 0.48\, kgm^2$$

$$\omega(t) = \frac{d\theta}{dt} = -5 + 6t^2$$

$$\omega(2) = -5 + 6 \times 2^2 = 19\, rad/s$$

$$K = \frac{1}{2} I\omega^2 = \frac{1}{2} \times 0.48 \times 361 = 86.6\, J$$

SP7: Two masses, $m_1 = 4\, kg$ and $m_2 = 14\, kg$, are connected by a light rope that passes over a fixed **frictionless and <u>massless</u> pulley**, as shown. **m_1 rests on m_2 and a force $|\vec{F}| = 28\, N$ is applied on m_1.** The surface between the two blocks is **rough (** $\mu_k = 0.25$). The surface on which m_2 rests is **frictionless**. **Find the magnitude of the system's acceleration (in m/s^2).**



For m_1

$$F - T - \mu_k m_1 g = m_1 a$$

$$18 - T = 4a$$

For m_2

$$T - \mu_k m_1 g = m_2 a$$

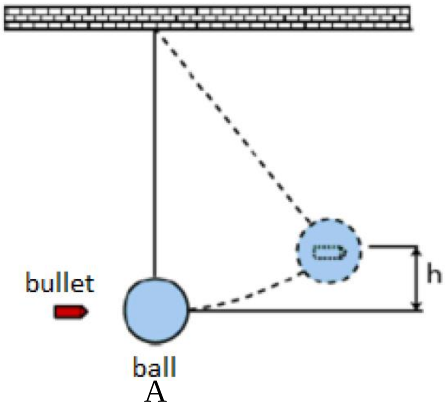
$$T - 10 = 14a$$

⇒ $a = 0.44\, m/s^2$

Part III: Long Problems (5 points each)

LP1. A bullet of mass of $m_1 = 50\ g$ moves horizontally with a speed of $v_1 = 250\ m/s$ makes a **completely inelastic collision** with a ball of mass $m_2 = 4\ kg$, suspended like a pendulum from a rope of length $L = 2\ m$. After the impact, the system swings up to a maximum height h, as shown.

a) What is the speed of the system v_2 <u>immediately after the collision</u>?



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

$$m_1 v_1 = (m_1 + m_2) v_2$$

$$v_2 = \frac{m_1 v_1}{m_1 + m_2} = \frac{0.05(250)}{4.05} = 3.1\ m/s$$

(b) Find the tension in the rope <u>immediately after the collision (at point A)</u>.

$$T - Mg = M\frac{v_2^2}{L}$$

$$T = M\left(g + \frac{v_2^2}{L}\right) = 4.05\left(10 + \frac{3.1^2}{2}\right) = 60\ N$$

(c) Find the maximum height (h) of the system.

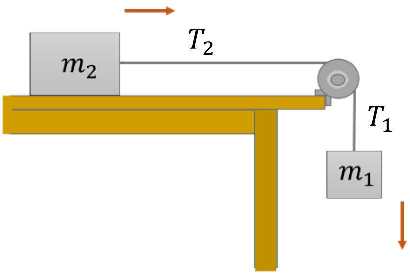
$$E_i = E_f$$

$$\frac{1}{2} M v_2^2 = Mgh$$

$$h = \frac{v_2^2}{2g} = \frac{3.1^2}{2(10)} = 0.48\ m$$

LP2. Two blocks ($m_1 = 6\ kg$, $m_2 = 4\ kg$) are connected by a light rope passing over a frictionless pulley with a radius $R = 0.3\ m$ and a moment of inertia $I = 1.44\ kg \cdot m^2$. The rope does not slip on the disk rim. The masses m_1 and m_2 are released **from rest**. The tabletop is **rough** ($\mu_k = 0.2$).

(a) If the tension in the vertical rope $T_1 = 48\ N$, find the acceleration of the system.



$$m_1 g - T_1 = m_1 a$$

$$a = g - \frac{T_1}{m_1} = 10 - \frac{48}{6} = 2\ m/s^2$$

(b) Find the tension in the horizontal part of the rope, T_2.

$$T_2 - \mu_k m_2 g = m_2 a$$

$$T_2 = m_2(a + \mu_k g) = 4(2 + 0.2(10)) = 16\ N$$

(c) Find the net torque (magnitude and direction) generated on the pulley.

$$\sum \tau = I\alpha = I\frac{a}{R}$$

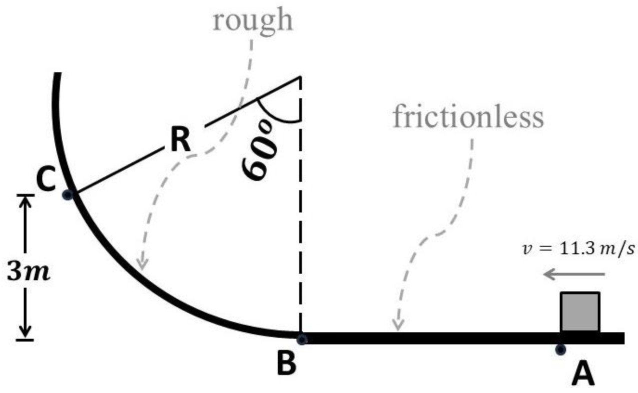
$$\sum \tau = 1.44 * \frac{2}{0.3} = 9.6\ N.m$$

into the page

or

$\sum \tau = (T_1 - T_2)R = (48 - 16)0.3 = 9.6\ N.m$, into the page.

LP3. A 2 kg block slides along a smooth surface before entering a **rough path** in the shape of a quarter circle of radius $R = 6\ m$, as shown. **The work done by friction** between point B and point C is $-36\ J$.



(a) Find the speed of the block at point C.

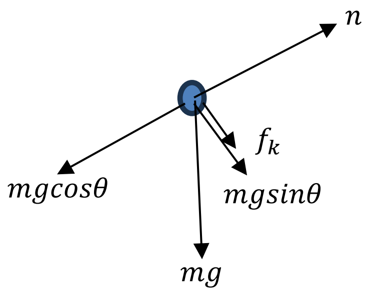
$$W_{fr} = E_c - E_A$$

$$W_{fr} = \frac{1}{2}mv_c^2 + mgy_C - \frac{1}{2}mv^2$$

$$-36 = \frac{1}{2}(2)v_c^2 + 2(10)(3) - \frac{1}{2}(2)(11.3)^2$$

$$v_c = 5.63\ m/s$$

(b) Draw a free-body diagram for the block at point C.

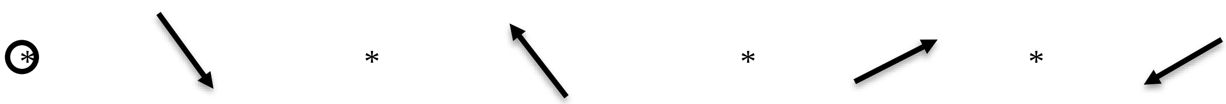


(c) Find the magnitude of the normal force at point C.

$$n_c - mg\cos 60 = \frac{mv_c^2}{R}$$

$$n_c = m(\frac{v_c^2}{R} + g\cos 60) = 2\left(\frac{5.63^2}{6} + 10\cos 60\right) = 20.7\ N$$

(d) Which of the following vectors represents the block's tangential acceleration direction at point C?

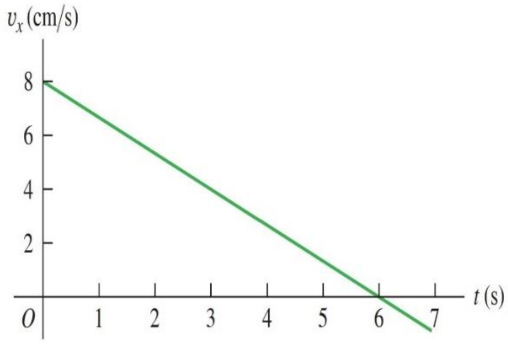


<u>Part III: Questions (Choose the correct answer, one point each)</u>

Q1. Which of the following is **NOT** an example of **a conservative force**?

* Gravitational force.
* Elastic force.
* Friction force.
* All of the above are examples of conservative forces.

Q2. A velocity-time graph for an object moving along the x-axis is shown below. At $t = 2$ s, t**he acceleration of the object is:**

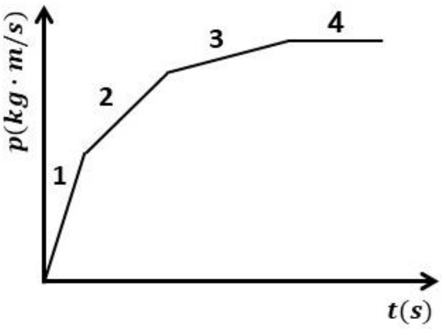


* Increasing in the $+x$ direction.
* Decreasing in the $+x$ direction.
* Constant in the $-x$ direction.
* Zero.

Q3. A and B are two wheels connected by a belt that does not slip and runs with **a constant linear speed v**. If $R_A = 2R_B$, then the relation between their angular accelerations α is:

* $\alpha_A = \alpha_B = 0$.
* $\alpha_A = \alpha_B \neq 0$.
* $\alpha_A = 2\alpha_B$.
* $\alpha_A = \frac{1}{2}\alpha_B$.

Q4. The **linear momentum** as a function of time is shown for an object moving along the +x axis. **In which region is the magnitude of the net force $|\vec{F}|$ on the object the greatest?**



* Region 1.
* Region 2.
* Region 3.
* Region 4.