Kuwait University　　　　Physics Department

جامعة الكويت
KUWAIT UNIVERSITY

Physics 101

Spring Semester
Final Exam
Tuesday, May 20, 2025
05:00 PM – 7:00 PM

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

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

Choose your Instructor's Name:

Instructors: Drs. Al Dosari, Alkurtass, 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
Pts	3	3	3	3	3	3	3	5	5	5	1	1	1	1	40

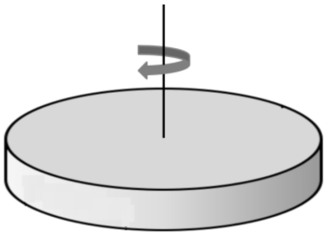
Important:

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 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: Short Problems (3 points each)

SP1. A wheel starts rotating from **rest** with a constant angular acceleration of $4\, rad/s^2$. **Find the number of revolutions of the wheel during the first 5 $seconds$**.



$$\Delta\theta = \omega_i t + \frac{1}{2}\alpha t^2$$

$$\Delta\theta = 0 + \frac{1}{2}(4)(5)^2 = 50\, Rad$$

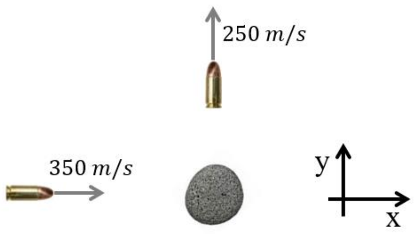
$$n = \frac{\Delta\theta}{2\pi} = \frac{50}{2\pi} = 8\, rev$$

SP2. A 0.1 kg stone **rests** on a frictionless **surface in the xy-plane**. A bullet of mass 6 g, traveling along the x-axis at 350 m/s, strikes the stone and rebounds **horizontally at a right angle** to its original direction with a speed of 250 m/s, as shown. **Find the velocity of the stone after it is struck in unit vector notation**.

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

$$(6\times10^{-3})(350\,\hat{\imath}) + 0 = (6\times10^{-3})(250\,\hat{\jmath}) + 0.1(\vec{v}_{2_f})$$

$$\vec{v}_{2_f} = (21\,\hat{\imath} - 15\,\hat{\jmath})\, m/s$$



SP3. Calculate the net torque (**magnitude and direction**) on the beam shown in the figure about an axis through point **O** perpendicular to the page. The beam and the three forces lie in **the plane of the page**.

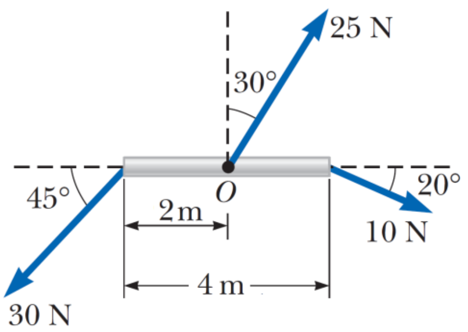
$$\sum \vec{\tau} = \vec{\tau}_1 + \vec{\tau}_2 + \vec{\tau}_3$$

$$= +F_1 r_1 \sin\theta_1 + F_2 r_2 \sin\theta_2 - F_3 r_3 \sin\theta_3$$

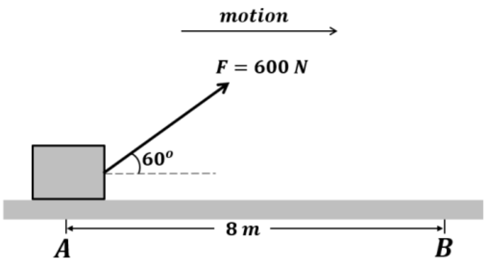
$$= +30\,(2)\sin 45^o + 25(0)\sin\theta_2 - 10(2)\sin 20^o$$

$$= +35.6\, N\cdot m \quad \text{(counterclockwise)}$$

(out pf page)



SP4. A force ($F = 600N$) is applied to a block moving with **constant velocity** on a **rough** horizontal surface, as shown. **Find the work done by the frictional force** on the block as it moves from point A to point B.



$$\sum W = 0$$

$$W_F + W_{f_k} = 0$$

$$W_{f_k} = -W_F = -Fd\cos(60^o)$$

$$= -600\ (8)\cos(60^o) = -\ 2400\ J$$

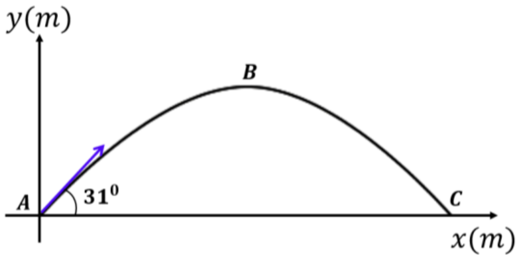
OR

$$a = 0 \Rightarrow \sum \vec{F} = 0$$

$$\Rightarrow |f_k| = F\cos(60^o) = 600\cos(60^o) = 300\ N$$

$$W_{f_k} = -|f_k|d = -300(8) = -2400\ J$$

SP5. A stone is projected from the ground at point A and reaches point C after 1.44 seconds. If the speed of the stone at its **maximum height** (point B) is 12 m/s, **find its velocity at point C** (just before it hits the ground) **in unit vector notation**.



$$v_y(B) = 0 \Rightarrow v(B) = v_x(B) = 12\ m/s$$

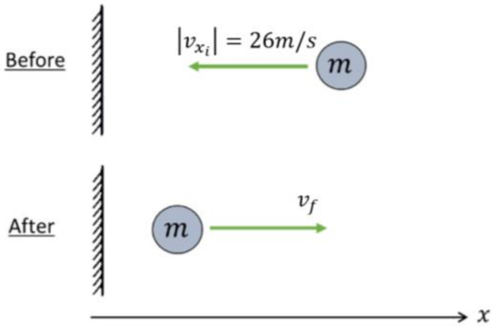
$$t_{B\rightarrow C} = \frac{1}{2}t_{A\rightarrow C} = 0.72\ s$$

$$v_y(C) = v_y(B) - gt = 0 - (10)(0.72) = -7.2\ m/s$$

$$v_{yx}(C) = v_x(B) = 12\ m/s$$

$$\vec{v}(C) = (12\hat{\imath} - 7.2\hat{\jmath})m/s$$

SP6. A ball of mass $m = 0.34\ kg$ is thrown against a brick wall and rebounds **horizontally**, as shown. The **time of contact** between the ball and the wall is $0.01\ s$ and the magnitude of the **average force** exerted on the ball during the impact is $1600\ N$. **Find the final velocity of the ball**.



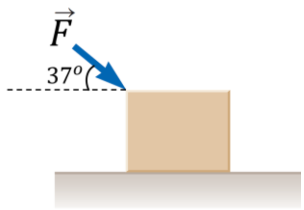
$$J_x = p_{f_x} - p_{i_x}$$

$$F_{av_x}\,\Delta t = m(v_{f_x} - v_{i_x})$$

$$(1600)(0.01) = (0.34)\{v_{f_x} - (-26)\}$$

$$v_{f_x} = +21\ m/s$$

SP7. A block of mass $m = 12\ kg$ is pushed by a force $F = 150\ N$ on a horizontal **rough surface**, as shown. The coefficient of kinetic friction between the block and the surface is $\mu_k = 0.5$. **Find the acceleration of the block.**



$$mg + F\sin(37^o) - n = 0$$

$$\Rightarrow n = mg + F\sin(37^o) = 12(10) + 150\sin(37^o) = 210.3\ N$$

$$F\cos(37^o) - \mu_k n = ma$$

$$\Rightarrow a = \frac{F\cos(37^o) - \mu_k n}{m} = \frac{150\cos(37^o) - 0.5(210.3)}{12} = 1.22\ m/s^2$$

Part II: Long Problems (5 points each)

LP1. A $4\ kg$ stone is moving in the $xy-plane$, its position vector as a function of time is given by $\vec{r}(t) = [(14+16t)\hat{\imath} - (3t)\hat{\jmath}]m$, where t is measured in $seconds$.

a) **Find the linear momentum of the stone in unit vector notation**.

$$\vec{v}(t) = \frac{d\vec{r}(t)}{dt} = [16\,\hat{\imath} - 3\,\hat{\jmath}]\ m/s$$

$$\vec{p} = m\vec{v} = [64\,\hat{\imath} - 12\hat{\jmath}]\ kg\cdot m/s$$

b) **Find the net force exerted on the stone**.

$$\vec{a}(t) = \frac{d\vec{v}(t)}{dt} = 0$$

$$\vec{F}_{net} = m\vec{a} = 0\ N$$

c) At a later time, the stone explodes into two fragments of equal mass. If the velocity of the first fragment immediately after the explosion is $\vec{v}_1 = [13\hat{\imath} - 5\hat{\jmath}]m/s$, **find the velocity of the second fragment just after the explosion in unit vector notation**.

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

$$M\vec{v}_i = m_1\vec{v}_1 + m_2\vec{v}_2$$

$$4(16\,\hat{\imath} - 3\hat{\jmath}) = 2(13\hat{\imath} - 5\hat{\jmath}) + 2\vec{v}_2$$

$$\vec{v}_2 = (19\,\hat{\imath} - \hat{\jmath})\ m/s$$

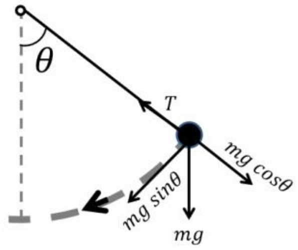
LP2. A light rope of length $2\ m$ is suspended from the ceiling, and a $4\ kg$ ball is attached to its lower end, forming **a simple pendulum**, as shown. The ball is **released from <u>rest</u>** at point A.

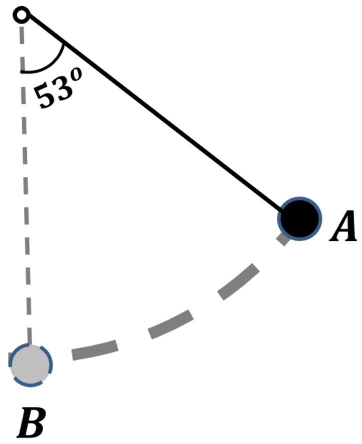
a) Find the tension in the rope at point A.

$T - mg\ cos\theta = 0$

$T = mg\ cos\theta = 4(10)\ cos53^o$

$= 24\ N$

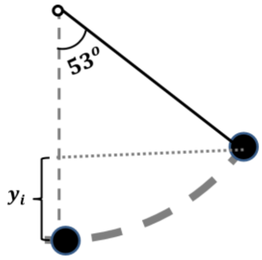




b) Find the speed of the ball at point B.

$y_i = L - L\cos 53^o = 0.8\ m$

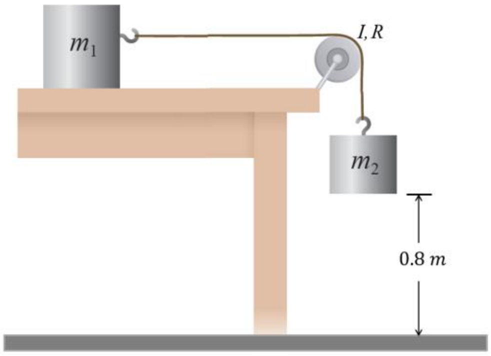
$mgy_i = \frac{1}{2}mv^2 \Rightarrow v = \sqrt{2gy_i} = 4\ m/s$



c) Find the work done by tension on the ball as it moves from point A to point B.

$W_T = 0\ (\varphi = 0)$

LP3. Two boxes ($m_1 = 12\ kg, m_2 = 18\ kg$) are attached by a light rope that passes over a pulley ($I = 5\ kg \cdot m^2, R = 0.4\ m$), as shown. **The tabletop is rough**. The system is released from **rest** when m_2 is $0.8\ m$ above the ground. Just before m_2 hits the ground, its speed is $2\ m/s$.



a) **Find the angular speed (ω_f) of the pulley just before m_2 hits the ground**.

$$\omega_f = \frac{v_f}{R} = \frac{2}{0.4} = 5\ rad/s$$

b) **Find the coefficient of kinetic friction (μ_k) between the tabletop and m_1.**

$$E_f \quad - \quad E_i \quad = \quad W_{f_k}$$

$$\frac{1}{2}(m_1 + m_2)v_f^2 + \frac{1}{2}I\omega_f^2 - m_2 g y_i = -\mu_k m_1 g d$$

$$\mu_k = \frac{m_2 g y_i - \frac{1}{2}(m_1 + m_2)v_f^2 - \frac{1}{2}I\omega_f^2}{m_1 g d} = \frac{18(10)(0.8) - \frac{1}{2}(30)2^2 - \frac{1}{2}(5)5^2}{12(10)(0.8)} = 0.22$$

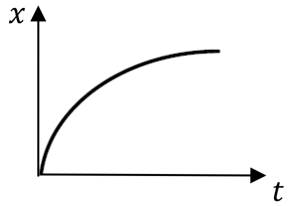
c) **Find the total work done on m_1 during this motion**.

$$W_{total} = \Delta K = \frac{1}{2}m_1\left(v_{1_f}^2 - v_{1_i}^2\right) = \frac{1}{2}12(2^2 - 0^2) = +24\ J$$

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

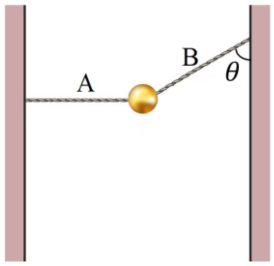
Q1. The graph of position versus time for a car is given below. What can you say about **the speed of the car** over the shown period of time?

* it speeds up all the time.
* it slows down all the time.
* it moves at a constant speed.
* it sometimes speeds up and sometimes slows down.



Q2: A ball of mass m is **held** in place by light steel cables. Cable B makes an angle θ with the wall, as shown. **The tension in cable A equals**

* mg
* $mg\ sin\ \theta$
* $mg\ cos\ \theta$
* $mg\ tan\ \theta$



Q3: Two **identical balls** are dropped from the **same height**. **Ball A** lands on **a hard surface** and bounces back, while **Ball B** lands on **a soft surface** and comes to rest without bouncing. **Which ball experiences the greater impulse ($\vec{J}$)** during the collision with the surface?

* Ball A.
* Ball B.
* Both balls experience the same impulse.
* Neither ball experiences impulse.

Q4. A block of mass m slides along a track, as shown. The track is frictionless except for the lower section, which is rough. The block comes to a stop over a distance D due to friction. If the block is replaced by another block of mass M (where $M > m$), the stopping distance D will

* increase
* decrease
* stay the same