Kuwait University Physics Department

Physics 121

Final Exam
Summer Semester (2025-2026)

July 26, 2026
Time: 06:00 – 08:00 PM

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

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

Instructors: Drs. Alotaibi, Alrefai, Burahmah, Hadipour, Kokkalis

Important:

1. Answer all questions and problems (No solution = no points).
2. Full mark = 40 points as arranged in the table below.
3. **Give your final answer in the correct units.**
4. Assume g = 9.8 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.**

For use by instructors

Grades:

#	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	Total
Pts	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**40**

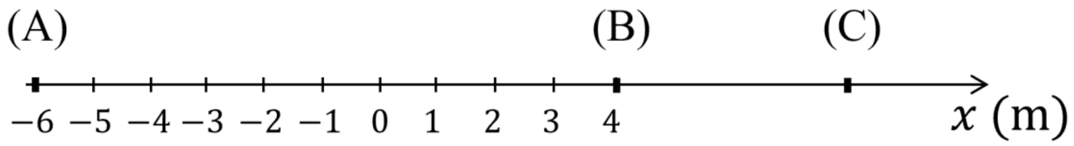
GOOD LUCK

P1. An object starts from rest at A and accelerates uniformly at $3\ \mathrm{m/s^2}$ until it reaches point B. At B, the object continues moving east while slowing down uniformly at $2\ \mathrm{m/s^2}$ until it stops at point C. Find:

a. The time taken to travel from A to B. **(1 point)**

b. The speed of the object at point B. **(1 point)**

c. The position of point C. **(2 points)**



(a) $A \rightarrow B: x = x_o + v_o t + \frac{1}{2}at^2 \rightarrow t = t_{A\rightarrow B} = 2.58\ s$

(b) $A \rightarrow B: v = v_o + at \rightarrow v = 0 + 3 \cdot 2.58 = 7.74\ m/s$

(c) $B \rightarrow C: v^2 = v_0^2 + 2a\Delta x \rightarrow \Delta x = \frac{v^2 - v_0^2}{2a} = \frac{0 - 7.74^2}{2(-2)} = 15\ m \rightarrow$

$x_c - x_B = 15\ m \rightarrow x_C = 15 + 4 = 19\ m$

P2. A student walks at constant speed along the paths $A = 200$ m, and $B = 400$ m, as shown. The total time of the trip is 10 minutes.

a. Find the magnitude of the student's total displacement ($\overrightarrow{D}$). **(3 points)**

b. Find the magnitude of the student's average velocity. **(1 point)**

(a) $D_x = A_x + B_x = A\sin(60^o) + B_x$

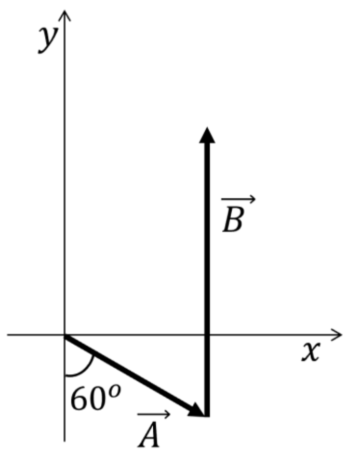
$= 200\sin(60^o) + 0 = 173.2\ m$

$D_y = A_y + B_y = -A\cos(60^o) + B_y$

$= -200\cos(60^o) + 400 = 300\ m$

$D = \sqrt{D_x^2 + D_y^2} = \sqrt{173.2^2 + 300^2} = 346.4\ m$

(b) $\bar{v} = \frac{\Delta x}{\Delta t} = \frac{346.4}{10\times 60} = 0.58\ m/s$

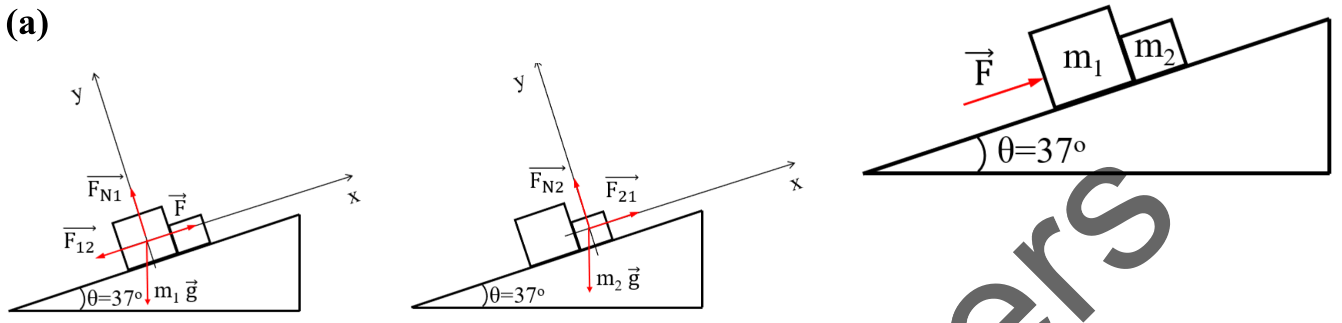


P3. Two masses $m_1 = 3.0$ kg and $m_2 = 2.0$ kg are in contact on a fixed smooth inclined surface. A force $\vec{F}$ with magnitude 39.4 N is applied on m_1 as shown below, accelerating both masses together up the incline.

a. **Draw the free-body-diagram of the masses m_1 and m_2.** **(1 point)**

b. **Find the acceleration of the mass m_1.** **(3 points)**

(a)



(b)(m_1) x-axis: $F - m_1 g \sin\theta - F_{12} = m_1 a$ (Eq. 1)

(m_2) x-axis: $F_{21} - m_2 g \sin\theta = m_2 a$ (Eq. 2)

Adding Eqs. (1) and (2) and since $F_{21} = F_{12}$

$$F - m_1 g \sin\theta - m_2 g \sin\theta = (m_1 + m_2)a$$

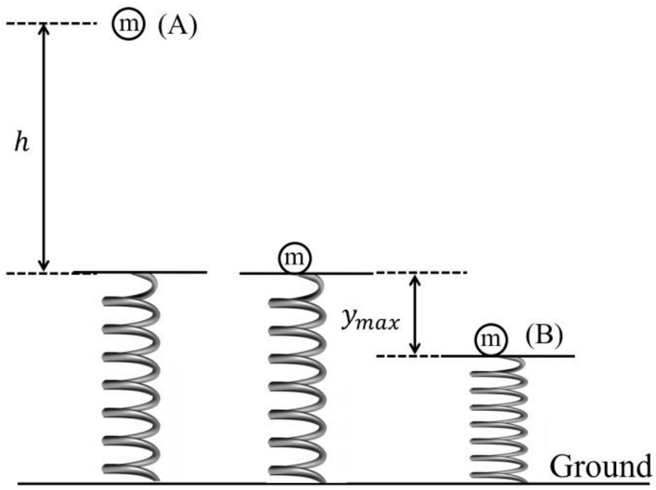
$$\rightarrow a = \frac{F - (m_1 + m_2) g \sin\theta}{(m_1 + m_2)} = 2\ m/s^2$$

P4. A $0.5-$kg ball is released from point A, located at a height $h = 1.2$ m above the top of an uncompressed vertical spring, as shown. The ball hits the spring and compresses it by a maximum distance of 0.2 m (point B). **Find the spring stiffness constant (k).** **(4 points)**

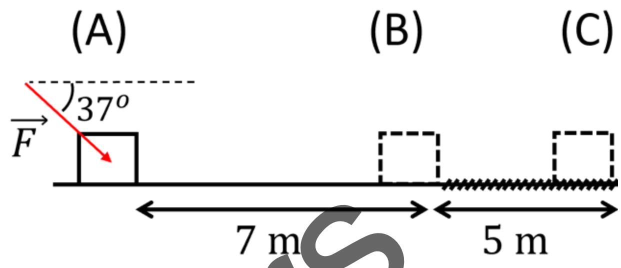
$$KE_A + PE_A = KE_B + PE_B$$

$$0 + mgh = 0 + \left(mg(-y) + \frac{1}{2}ky^2\right)$$

$$\rightarrow k = \frac{2mg(h+y)}{y^2} = 343\ N/m$$



P5. An $80 - \text{kg}$ box is initially at rest at point A. A constant force of $120\ \text{N}$ is pushing the box over a total distance of $12\ \text{m}$, as shown. For the first $7\ \text{m}$ (A to B) the floor is smooth and the last $5\ \text{m}$ (B to C) the floor is rough. The speed of the box at point C is $2\ \text{m/s}$. **Find the coefficient of kinetic friction (μ_k) for the rough surface.** **(4 points)**



From point A to C

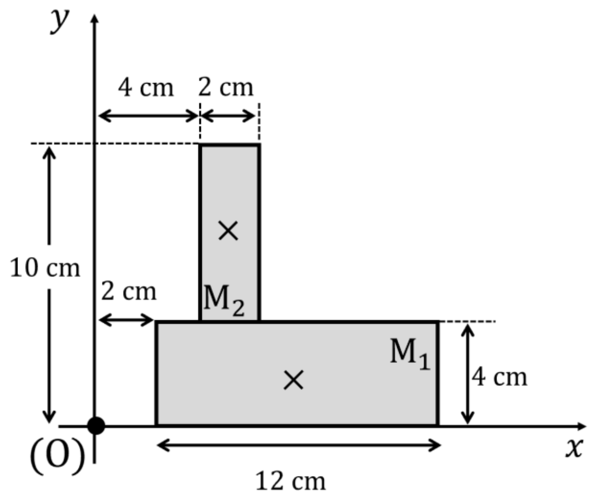
$$W_{NC} = \Delta KE + \Delta PE \rightarrow$$

$$W_F + W_{F_{fr}} = \left(\frac{1}{2}mv_C^2 - 0\right) + 0 \rightarrow$$

$$F \times AC \times \cos 37° - (mg + F\sin 37°)\mu_k \times BC = \frac{1}{2}mv_C^2$$

$$\mu_k = 0.23$$

P6. A structure made up by two uniform rectangular plates is shown below. The two plates have masses $M_1 = 3$ kg and $M_2 = 1$ kg. **Find the x −coordinate and y −coordinate of the center-of-mass of the structure, measured from the origin (point O)**. **(4 points)**



$$X_{CM} = \frac{x_1M_1 + x_2M_2}{M_1 + M_2} = \frac{8 \times 3 + 5 \times 1}{3 + 1} \rightarrow X_{CM} = 7.25\ cm$$

$$Y_{CM} = \frac{y_1M_1 + y_2M_2}{M_1 + M_2} = \frac{2 \times 3 + 7 \times 1}{3 + 1} \rightarrow Y_{CM} = 3.25\ cm$$

	$x\ (cm)$	$y\ (cm)$
M_1	$2 + \frac{12}{2} = 8$	$\frac{4}{2} = 2$
M_2	$4 + \frac{2}{2} = 5$	$4 + \frac{10-4}{2} = 7$

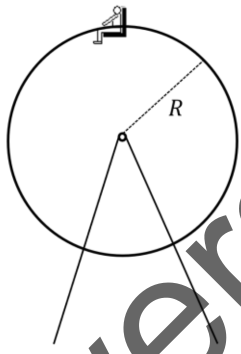
P7. A Ferris wheel of radius 15.0 m rotates at a constant angular speed of 0.200 rad/s. A passenger of mass 60.0 kg is seated in one of the cabins.

a. Find the passenger's apparent weight when he is at the topmost position. (2 points)

b. When the motor is switched off the wheel slows down with constant angular acceleration of magnitude $0.001\ \mathrm{rad/s^2}$. Find the number of revolutions completed by the Ferris wheel before it comes to rest. (2 points)

(a) $mg - F_N = m\frac{v^2}{R} = m\omega^2 R$

$\rightarrow F_N = mg - m\omega^2 R = 552\ N$



(b) $\omega_f^2 = \omega_i^2 + 2\alpha\Delta\theta \rightarrow \Delta\theta = \frac{\omega_f^2 - \omega_i^2}{2\alpha}$

$\rightarrow \Delta\theta = \dfrac{0 - 0.2^2}{2(-0.001)} = 20\ rad$

$N = \dfrac{\Delta\theta}{2\pi} \rightarrow N = 3.18\ revolutions$

P8. A person holds a ball while keeping his forearm horizontal, as shown. The forearm has a weight of 15 N, and its center of mass is 15 cm from the elbow joint (*O*). The ball has a weight of 20 N and is held 35 cm from the elbow joint. The biceps tendon is attached 4 cm from *O* and exerts an upward force $\overrightarrow{F_B}$.

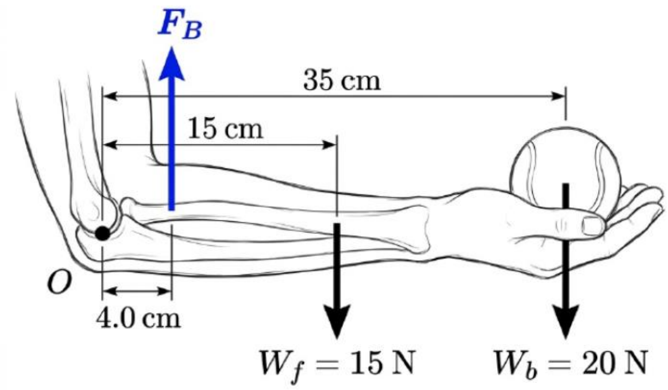
a. Find the magnitude of the biceps force ($\overrightarrow{F_B}$). (2 points)

b. Find the force exerted by the elbow joint on the forearm. (2 points)

(a) The second condition of equilibrium ($\tau_{net} = 0$) about elbow joint:

$F_B \times 0.040 - 15 \times 0.15 - 20 \times 0.35 = 0$

$\rightarrow F_B = 231\ N$



(b) The first condition of equilibrium:

$F_J + F_B - 15 - 20 = 0 \rightarrow$

$F_J = -196\ N$, direction is downward

P9. Water ($\rho = 10^3$ kg/m^3) flows steadily from a wider section of a pipe at ground to a narrower section located 5 m above it. The pipe radius decreases from 8 cm to 4 cm. The speed of the water in the wider section is 2.0 m/s, and the pressure there is 150 kPa.

a. Find the speed of the water in the narrower section. (2 points)

b. Find the pressure in the narrower section. (2 points)

(a)

$$A_1 v_1 = A_2 v_2 \Rightarrow v_2 = \frac{A_1}{A_2} v_1 = \frac{\pi 0.08^2}{\pi 0.04^2}(2) = 8\ m/s$$

(b)

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g y1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y2 \rightarrow$$

$$P_2 = 71\ kPa$$

P10. The position of a $0.5 -$ kg mass undergoing simple harmonic oscillation is described by $x = 0.3 \cdot \cos(8.0 \cdot t)$ where x is in meters and t is in seconds.

a. Find the time required for the mass to move from $x = 0.3$ m to $x = 0$ for the first time. (2 points)

b. Find the spring constant (k). (1 point)

c. Find the maximum speed of the mass. (1 point)

(a) The time it takes to go from the maximum displacement to the equilibrium position is a quarter of period. $\omega = \frac{2\pi}{T} \rightarrow T = \frac{2\pi}{\omega} = \frac{2\pi}{8} = 0.79\ s \rightarrow \Delta t = \frac{T}{4} = 0.196\ s$

(b)

$$T = 2\pi\sqrt{\frac{m}{k}} \rightarrow \frac{k}{m} = \left(\frac{2\pi}{T}\right)^2 \rightarrow k = 31.6\ N/m$$

(c)

$$\frac{1}{2} m v_{max}^2 = \frac{1}{2} k A^2 \rightarrow v_{max} = A\sqrt{\frac{k}{m}} = 2.38\ m/s$$