Kuwait University **Physics Department**

جامعة الكويت
KUWAIT UNIVERSITY

Physics 121

Final Exam
Spring Semester (2025-2026)

May 14, 2026
Time: 09:00 – 11:00 AM

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

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

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

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	**5**	**5**	**5**	**3**	**4**	**4**	**4**	**3**	**3**	**4**	**40**

GOOD LUCK

P1. A bicycle starts from rest at point A (0, −6 m) and moves toward point B (0, 0) with constant acceleration $4\ \mathrm{m/s^2}$. At point B the cyclist begins to brake uniformly at a rate of $2\ \mathrm{m/s^2}$ until coming to rest at point C. The whole motion is along y-axis. Find:

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

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

c. The position of point C. **(1 point)**

d. The average velocity for the whole trip. **(2 points)**

(a) $A \to B: y = y_o + v_o t + \frac{1}{2} a t^2 \to t = t_{A\to B} = 1.73\ s$

(b) $A \to B: v = v_o + at \to v = 0 + 4 \cdot 1.73 = 6.92\ m/s$

(c) $B \to C: v^2 = v_0^2 + 2a\Delta y \to \Delta y = \frac{v^2 - v_0^2}{2a} = \frac{0 - 6.92^2}{2(-2)} = 12\ m \to y_c = +12\ m$

(d) $B \to C: v = v_o + at \to t = t_{B\to C} = \frac{v - v_o}{a} = \frac{0 - 6.92}{-2} = 3.46\ s$

$t_{total} = t_{A\to B} + t_{B\to C} = 1.73 + 3.46 = 5.19\ s$

$$A \to C: \bar{v} = \frac{\Delta y}{\Delta t} = \frac{y_C - y_A}{t_{total}} = \frac{12 - (-6)}{5.19} = 3.46\ m/s$$

P2. A student walks with constant speed by following the paths $A = 200$ m, and $B = 400$ m, as shown. The total time of the trip is 0.5 h.

a. Find the magnitude of the students total displacement ($\vec{D}$). **(3 points)**

b. Find the direction of vector $\vec{D}$. **(1 point)**

c. Find the average speed of the student. **(1 point)**

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

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

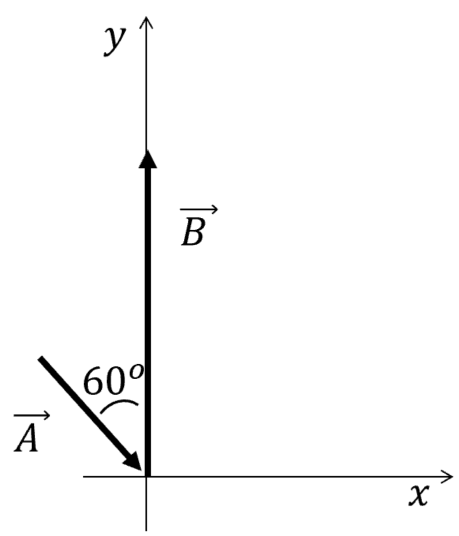
$D_y = A_y + B_y = -A\cos(60^o) + B_y$

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

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

(b) $\theta = \tan^{-1}\left(\frac{D_y}{D_x}\right) = 60^o$

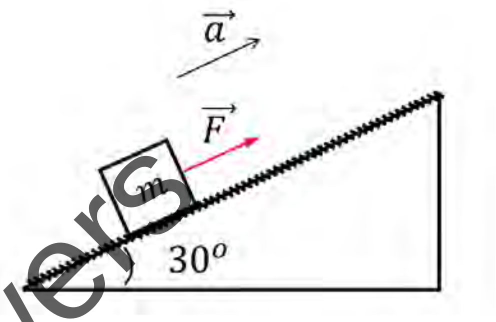
(c) $average\ speed = \frac{Total\ Distance}{Time} = \frac{200+400}{0.5\times 3600} = 0.33$ m/s



P3. A 12 kg box is placed on a 30^o incline with a rough surface. A constant force of magnitude $F = 180$ N is applied on the box as shown below. The coefficients of friction are $\mu_s = 0.4$ and $\mu_k = 0.3$.

a. Determine whether the box moves by the applied force. Justify your answer with calculations. (3 points)

b. If the box moves, find its acceleration. If it does not move, find the static force of friction. (2 points)



(a) $(\text{F}_{fr,s})_{max} = F_N\mu_s = mgcos(30)\mu_s = 40.7\ N$

$F - mgsin(30) = 121.2\ N$

$F - mgsin(30) > (\text{F}_{fr,s})_{max} \rightarrow$ The box moves

(b)

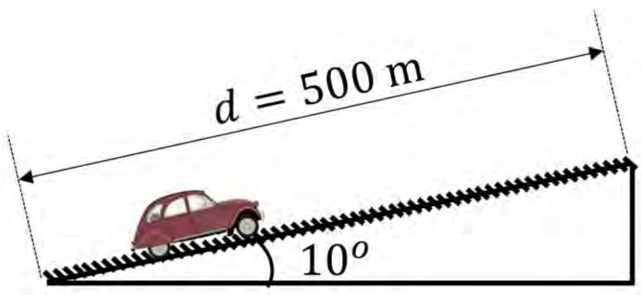
$\Sigma F_x = ma_x \rightarrow F - mgsin(30) - F_{fr,k} = ma \rightarrow$

$$a = \frac{F - mgsin(30) - mgcos(30)\mu_k}{m} = 7.55\ m/s^2$$

P4. A 1000 kg car is driven up a ramp at 10^o. In 50 s, the car moves 500 m along the ramp at constant speed. A net friction force of 800 N acts opposite to the motion. During this motion find:

a. The work done by the engine force. (2 points)

b. The average power delivered by engine. (1 point)



(a) $F_{eng} - F_{fr} - mgsin(10^o) = ma \rightarrow$

$F_{eng} = F_{fr} + mgsin(10^o) = 2.5 \times 10^3 N$

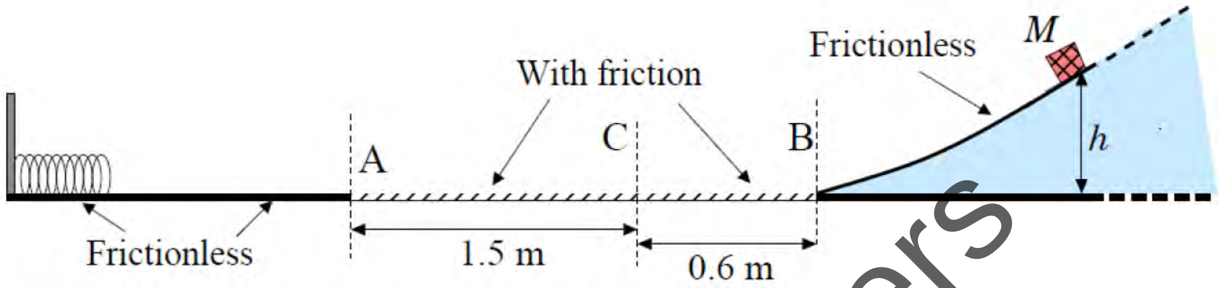
$W_{F_{eng}} = F_{eng}d = 1.25 \times 10^6 J$

(b) $\bar{P}_{F_{eng}} = \frac{W_{F_{eng}}}{t} = \frac{1.25\times10^6}{50} = 2.5 \times 10^4\ W$

P5. A box (mass M = 2 kg) is released from rest at a height of h = 1.3 m on a frictionless incline. It reaches point B and then moves along a rough horizontal surface of length AB = 2.1 m. After reaching point A, the box continues on a frictionless horizontal surface and compresses a spring by 5 cm, where it momentarily comes to rest. The mass then rebounds and finally stops at point C.

a. Find the coefficient of kinetic friction (μ_k) for the rough surface. (2 points)

b. Find the spring constant. (2 points)



(a) From starting point until point C

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

$W_{F_{Fr}} = (0-0) + ((0+0) - (0 + Mgh)) \rightarrow$

$-Mg\mu_k(BA + AC) = -Mgh \rightarrow \mu_k = 0.361$

(b) From max. compression until point C

$$W_{NC} = \Delta KE + \Delta PE \rightarrow W_{F_{Fr}} = (0-0) + \left((0+0) - (0 + \frac{1}{2}kx^2)\right)$$

$$\rightarrow -Mg\mu_k AC = -\frac{1}{2}kx^2 \rightarrow k = \frac{2 \cdot Mg\mu_k AC}{x^2} = 8491\ N/m$$

P6. A motor rotates a wheel uniformly through 20 revolutions in 5 seconds. When the motor is switched off, the wheel rotates with constant angular acceleration and comes to rest after 6 revolutions.

a. For a point on the disk located 2 cm away from the axis of rotation, find the centripetal acceleration while the wheel is rotating uniformly. (2 points)

b. Find the angular acceleration (α) of the wheel. (2 points)

(a) $\omega = 2\pi f = 2\pi \frac{20}{5} = 8\pi \frac{rad}{s}$

$a_R = \omega^2 R = 12.6\, m/s^2$

(b) $N = \frac{\Delta\theta}{2\pi} \rightarrow \Delta\theta = 12\pi\, rad$

$$\omega_f^2 = \omega_i^2 + 2\alpha\Delta\theta \longrightarrow \alpha = \frac{\omega_f^2 - \omega_i^2}{2\Delta\theta} = \frac{0-(8\pi)^2}{2(12\pi)} = -8.4\, rad/s^2$$

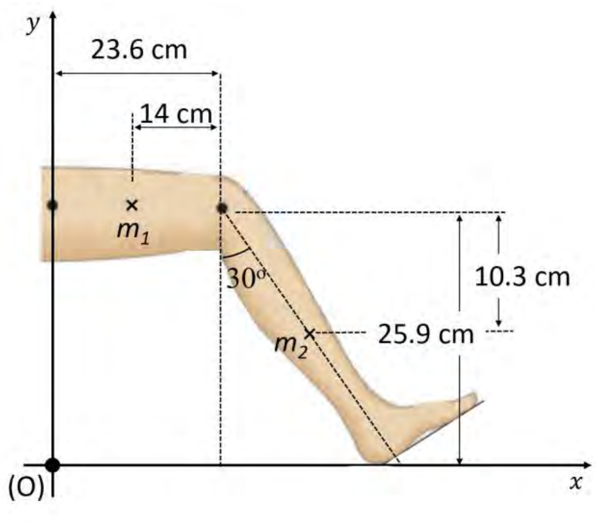
P7. A leg of an athlete is bent during a stretching position as shown below. The upper leg has mass $m_1 = 15.1$ kg, while the mass of the lower leg and feet together is $m_2 = 9.1$ kg. **Find the x −coordinate and y −coordinate of the center-of-mass of the leg, measured from the origin (point O)**. **(4 points)**

$$X_{CM} = \frac{x_1 m_1 + x_2 m_2}{m_1 + m_2} = \frac{9.6 \times 15.1 + 29.5 \times 9.1}{15.1 + 9.1}$$

$\rightarrow X_{CM} = 17\ cm$

$$Y_{CM} = \frac{y_1 m_1 + y_2 m_2}{m_1 + m_2} = \frac{25.9 \times 15.1 + 15.6 \times 9.1}{15.1 + 9.1}$$

$\rightarrow Y_{CM} = 22\ cm$

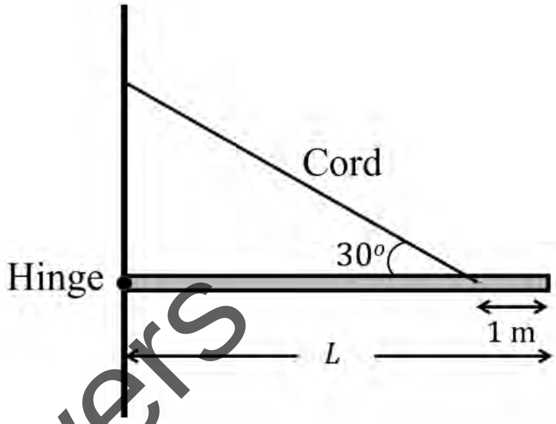


	$x\ (cm)$	$y\ (cm)$
m_1	$23.6 - 14 = 9.6$	25.9
m_2	$23.6 + \tan(30^o) \times 10.3 = 29.5$	$25.9 - 10.3 = 15.6$

P8. A uniform horizontal beam of mass $m = 200$ kg and length $L = 6$ m is hinged to a wall. A cord is attached to the beam at a point 1 m from the free end, as shown. The cable makes an angle of 30^o with the beam. The structure is in equilibrium.

a. Find the tension in the cord. **(2 points)**

b. Find the y −component of the force exerted by the hinge. **(1 point)**



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

$$F_T \times (L-1) \times \sin 30^o - mg \times \frac{L}{2} = 0$$

$$\rightarrow F_T = \frac{mg \times \frac{L}{2}}{(L-1) \times \sin 30^o} = 2352\ N$$

(b) The first condition of equilibrium:

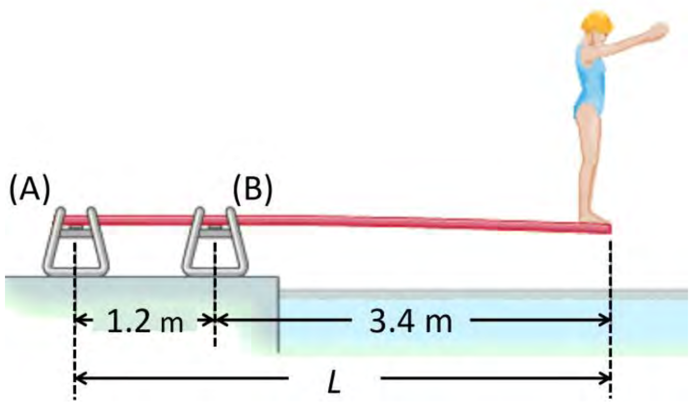
$$F_{Hy} + F_T \sin 30^o - mg = 0 \rightarrow F_{Hy} = 784\ N$$

P9. A uniform board of length $L = 4.6$ m and mass m $= 52$ kg is supported at point A and B, as shown. The distance between points A and B is 1.2 m and the end of the board is 3.4 m to the right of B. A diver of mass M stands at the right end of the board. If support A can withstand a maximum force of 2500 N, **find the maximum mass M of the diver.** **(3 points)**

The second condition of equilibrium ($\tau_{net} = 0$) about point (B):

$$F_A \times 1.2 - mg \times \left(\frac{4.6}{2} - 1.2\right) - Mg \times 3.4 = 0$$

$$\rightarrow M = \frac{F_A \times 1.2 - mg \times \left(\frac{4.6}{2} - 1.2\right)}{g \times 3.4} = 73\ kg$$



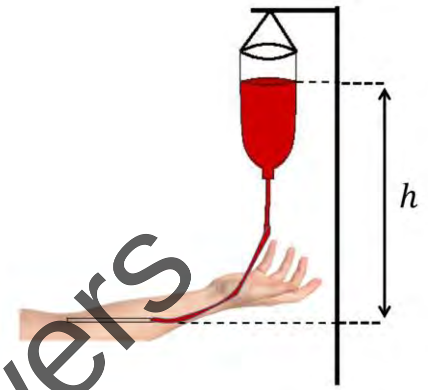
P10. Intravenous (IV) infusion is done under gravity as shown below. The blood pressure in the vein is 60 mm Hg (1 mm Hg = 133 Pa) and the IV fluid density is $1050\ \mathrm{kg/m^3}$.

a. Find the minimum height above the vein at which the bottle must be placed so the fluid barely enters the vein. (2 points)

b. If the fluid speed inside the needle is $0.4\ \mathrm{cm/s}$ and the inner radius of the needle is 0.4 mm, find the volume flow rate of the fluid through the needle. (2 points)

(a) $\Delta P = \rho g h \rightarrow h = \frac{\Delta P}{\rho g} \rightarrow$

$$\frac{60 \times 133}{1050 \times 9.8} = 0.78\ m$$



(b)

$Q = Av = \pi r^2 v \rightarrow$

$Q = \pi(4 \times 10^{-4})^2 0.4 \times 10^{-2} = 2 \times 10^{-9} m^3/s$