Kuwait University جامعة الكويت KUWAIT UNIVERSITY **Physics Department**

Physics 121

Final Exam
Fall Semester (2025-2026)

December 30, 2025
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	**4**	**3**	**4**	**4**	**4**	**4**	**5**	**3**	**4**	**5**	**40**

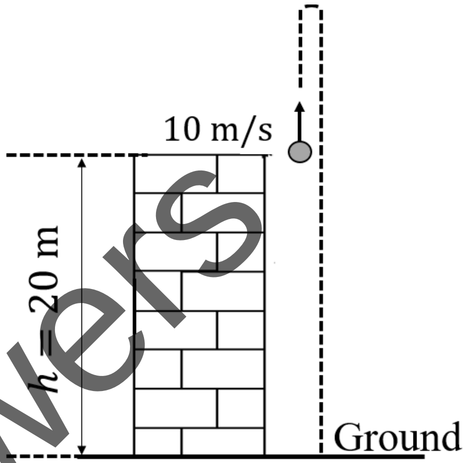
GOOD LUCK

P1. A rock is thrown straight up from the top of a 20 m tall building with an initial speed of 10 m/s. Ignore air resistance. Find:

a. The speed of the rock just before it hits the ground. (1 point)

b. The time it takes for the rock to fall from the highest point to the ground. (1 point)

c. The average velocity of the rock, for the motion between the highest point to the ground. (2 points)



Taking $+y$ direction upwards and origin to be at the top of the building.

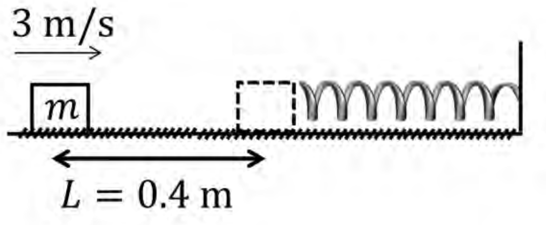
(a) $v_f^2 = v_0^2 + 2a\Delta y \rightarrow v_f = \sqrt{(10)^2 + 2 \times (-9.8) \times (-20)} = 22.2\ m/s$

(b) $v = v_o + at \rightarrow t = \frac{-22.2-0}{-9.8} = 2.3\ s$

(c) $v_f^2 = v_0^2 + 2a\Delta y \rightarrow h_{max} = \frac{v_f^2 - v_0^2}{2a} = \frac{0-10^2}{2(-9.8)} = 5.1\ m$

$$\bar{v} = \frac{\Delta y}{\Delta t} = \frac{-20-(+5.1)}{2.3} = -11.1\ m/s$$

P2. A $1.5-$kg block slides on a horizontal rough surface towards a spring of constant 650 N/m. At a distance of 0.40 m from the free end of the unstretched spring, the speed of the block is 3.0 m/s. The maximum compression of the spring is 0.12 m. **Find the coefficient of kinetic friction between the block and the surface. (3 points)**



$$W_{NC} = \Delta KE + \Delta PE \rightarrow F_{fr}(L+x)\cos(180) = -\frac{1}{2}mv^2 + \frac{1}{2}kx^2 \rightarrow$$

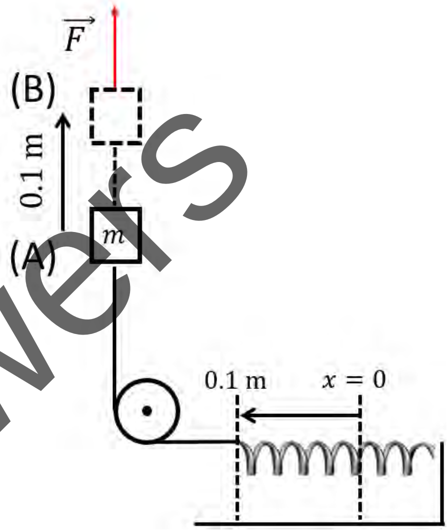
$$-\mu_k mg(L+x) = -\frac{1}{2}mv^2 + \frac{1}{2}kx^2$$

$$\rightarrow \mu_k = 0.27$$

P3. A $20-$ kg mass is connected to a massless spring ($k = 380$ N/m), by a massless cord over a frictionless pulley. The spring is initially at equilibrium. A vertical pulling force $\vec{F}$ lifts the mass from rest at point A to point B, 0.1 m higher. At B, the speed of the mass is 3 m/s.

a. Find the work done by the force $\vec{F}$ during this motion. (2 points)

b. Find the magnitude of the average power delivered by the force of gravity during this motion, taken to be 0.07 s. (2 points)



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

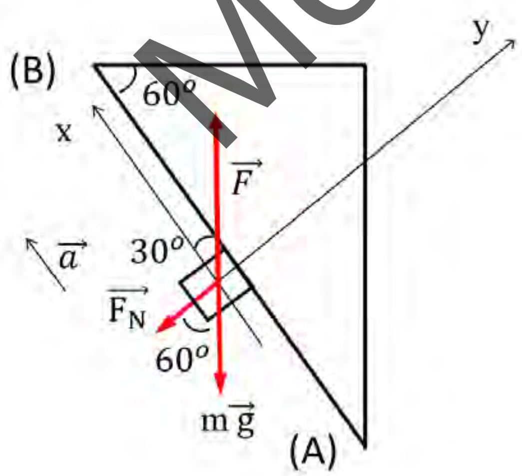
$$W_F = \left(\frac{1}{2}mv^2 - 0\right) + \left(mgy + \frac{1}{2}kx^2\right) = 111.5\,J$$

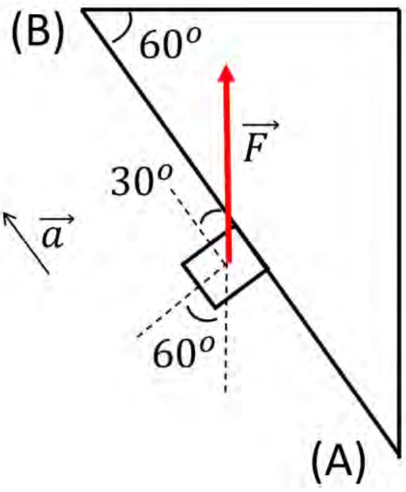
(b) $P_{F_G} = \frac{W_{F_G}}{t} = \frac{m \cdot g \cdot y}{t} = 280\,W$

P4. A $5-$kg block moves on a frictionless incline that makes an angle of 60^o with the horizontal. A constant force of magnitude $F = 60$ N is applied to the block at an angle of 30^o with respect to the incline, accelerating it uniformly up the plane, as shown. The block remains in contact with the surface during the motion.

a. Draw the free-body diagram of the mass. (1 point)

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





(b)

$$\Sigma F_x = ma_x \rightarrow Fcos(30) - mgsin(60) = ma$$

$$Fcos(30) - mgsin(60) = ma$$

$$a = \frac{Fcos(30) - mgsin(60)}{m} = 1.9\, m/s^2$$

P5. A structure made up of two uniform rectangular pieces is shown below. The two pieces have mass $M_1 = 3$ 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)**

$$X_{CM} = \frac{x_1 M_1 + x_2 M_2}{M_1 + M_2}$$

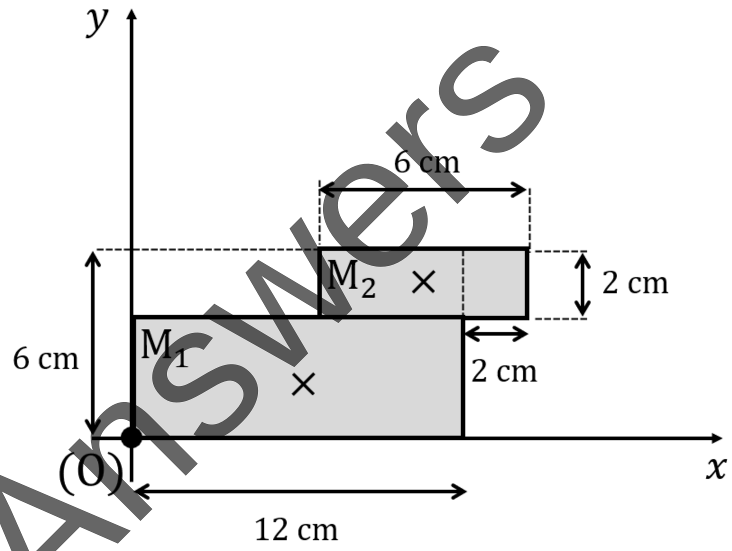
$$= \frac{6 \times 3 + 11 \times 1}{3 + 1}$$

$$\rightarrow X_{CM} = 7.25cm$$

$$Y_{CM} = \frac{y_1 M_1 + y_2 M_2}{M_1 + M_2}$$

$$= \frac{2 \times 3 + 5 \times 1}{3 + 1}$$

$$\rightarrow Y_{CM} = 2.75\ cm$$

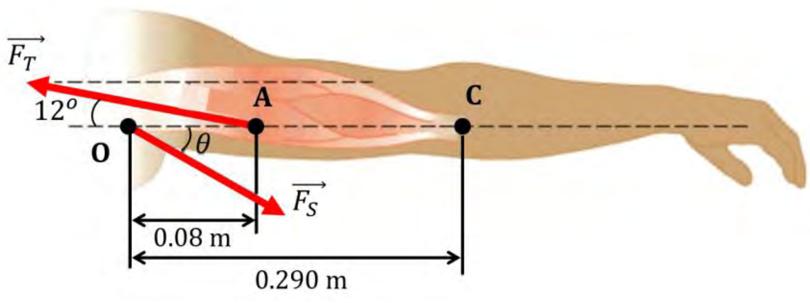


	$x\ (cm)$	$y\ (cm)$
M_1	$\frac{12}{2} = 6$	$\frac{6-2}{2} = 2$
M_2	$12 + 2 - 6 + \frac{6}{2} = 11$	$4 + \frac{2}{2} = 5$

P6. A person holds his arm horizontally in equilibrium, as shown. The mass of the arm is $m =$ 3.5 kg and its center of mass is at point C. The tendon exerts a force $\overrightarrow{F_T}$ at an angle of 12° above the horizontal (point A), while the shoulder joint force is $\overrightarrow{F_S}$ (point O).

a. Find the magnitude of the tendon force (F_T). (3 points)

b. Find the vertical component of the shoulder joint force (F_{Sy}). (1 point)



(b)About O: $\Sigma\tau = 0 \rightarrow 0 + F_{T_y} \times 0.08 - F_G \times 0.29 = 0 \rightarrow F_{T_y} = 124.3$ N

$$F_{T_y} = 124.3 \text{ N} = F_T \sin(12) \rightarrow F_T = 598\ N$$

(c) $\Sigma F_y = 0 \rightarrow F_{Ty} - F_{S_y} - mg = 0 \rightarrow F_{S_y} = F_{Ty} - mg = 90$ N

P7. A rotating disk of radius $R = 1.2$ m accelerates uniformly from rest to a tangential (rim) speed of 3.0 m/s in 0.5 s.

a. Find the angular acceleration α. (2 points)

b. Find the number of revolutions made during this time. (1 point)

c. At $t = 0.5$ s, find the magnitude of the total acceleration of a point on the rim of the disk. (2 points)

(a) $\omega_f = \frac{v_f}{R} = 2.5 \frac{rad}{s},\ \alpha = \frac{\Delta\omega}{t} = 5\ rad/s^2$

(b)$\omega_f^2 = \omega_i^2 + 2\alpha\Delta\theta \longrightarrow \Delta\theta = 0.625\ rad, N = \frac{\Delta\theta}{2\pi} = 0.1$

(c) $a_R = \frac{v^2}{R} = 7.5 \frac{m}{s^2}\ , a_t = R\alpha = 6.0\ \frac{m}{s^2}\ \ , a_{tot} = \sqrt{a_R^2 + a_t^2} = 9.6\ \frac{m}{s^2}$

P8. Water ($\rho = 10^3$ kg/m^3) fills a tank of height 0.5 m and bottom surface area of 10 m^2.

a. Find the average volume flow rate required to fill the tank in 2 hours. (2 points)

b. Find the gauge pressure at the bottom when the tank is full. (1 point)

$$Q = \frac{\Delta V}{\Delta t} = \frac{A \cdot h - 0}{t}$$

$$\rightarrow Q = 6.9 \cdot 10^{-4} m^3/s$$

$$P = \rho \cdot g \cdot h \rightarrow P = 4.9 \cdot 10^3\ Pa$$

P9. Water ($\rho = 10^3$ kg/m^3) flows through a pipe that changes in height and cross-sectional area. At point 1, the pipe is at height $y_1 = 1.0$ m and the fluid speed is $v_1 = 2$ m/s. At point 2, the pipe is at $y_2 = 3.0$ m and the fluid speed is $v_2 = 4$ m/s.

a. Find the pressure difference ($P_1 - P_2$) between the two points. (2 points)

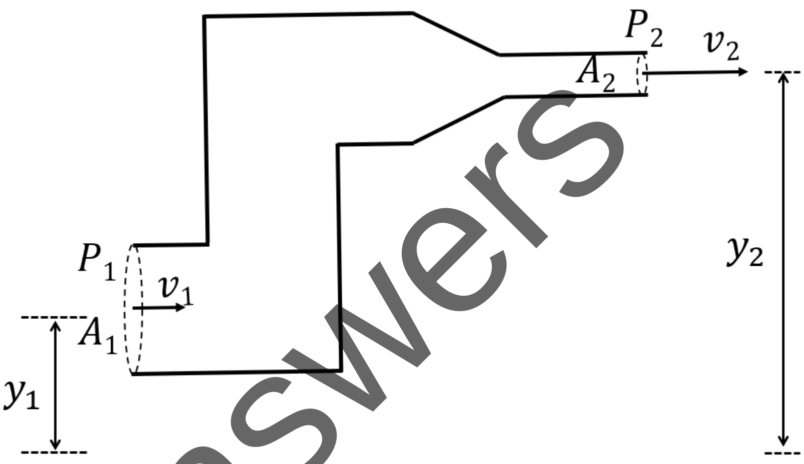
b. The radius of the pipe at point 2 is 0. 5 m. Find the cross-section area at point 1. (2 points)

$$P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2 = P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1$$

$$P_1 - P_2 = \frac{1}{2}\rho(v_2^2 - v_1^2) + \rho g(y_2 - y_1) = 25600\ Pa$$

$$A_2 \cdot v_2 = A_1 \cdot v_1 \rightarrow$$

$$\rightarrow A_1 = \frac{\pi r_2^2 \cdot v_2}{v_1} = 1.57\ m^2$$



P10. A particle of mass $m = 1.0$ kg is attached to a spring with spring constant 100 N/m. The total energy of the system is 5 J. The particle performs **simple harmonic motion** on a surface starting from the equilibrium position.

a. Find the amplitude of the motion. (1 point)

b. Find the maximum speed of the particle. (1 point)

c. Find the maximum acceleration (magnitude) of the particle. (1 point)

d. Find the equation of the particle position as a function of time. (2 points)

(a) $E = \frac{1}{2}kA^2 \rightarrow A = \sqrt{\frac{2E}{k}} = 0.32\ m$

(b) $\frac{1}{2}kv_{max}^2 = \frac{1}{2}kA^2 \rightarrow v_{\max} = A\sqrt{\frac{k}{m}} = 3.16\ m$

(c) $a_{max} = \frac{F_{max}}{m} = \frac{kA}{m} = 31.6\ m/s^2$

(d) $\omega = \sqrt{\frac{k}{m}} = 10\frac{rad}{s}, x(t) = 0.32\ \sin\ (10\ t)$