Kuwait University Physics Department

Physics 121

Final Exam
Summer Semester (2023-2024)

July 29, 2024
Time: 08:00 – 10:00

Student's Name: ……..……..…… Serial No: ……

Student's Number: ….…… Section No: ……

Instructors: Drs. Alotaibi, Afrousheh, Alsmadi, and Hadipour,

---

Important Instructions to the Students:

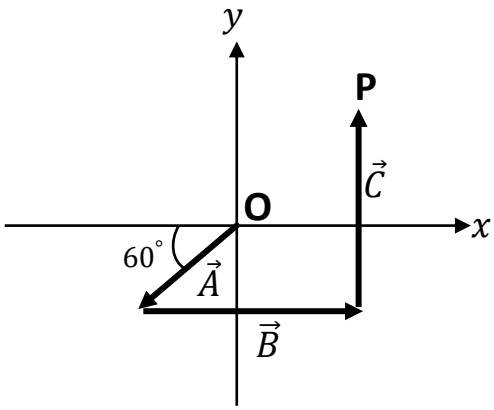
1. Answer all questions and problems.
2. Full mark = 40 points
3. No solution = no points.
4. **Use SI units.**
5. Take g = 9.8 m/s^2.
6. Mobiles are **strictly prohibited** during the exam.
7. Programmable calculators, which can store equations, are not allowed.
8. **Cheating incidents will be processed according to the university rules.**

For use by Instructors only

#	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	Total
Pts	4	4	3	4	4	4	4	4	4	5	40

GOOD LUCK

P1. A cat walks from point **O** to point **P** by following paths of lengths $A = 20$ m and $B = 30$ m and $C = 40$ m as shown in total time of 2 minutes. Find the average velocity of the cat's whole trip from point **O** to point **P**. (4 points)



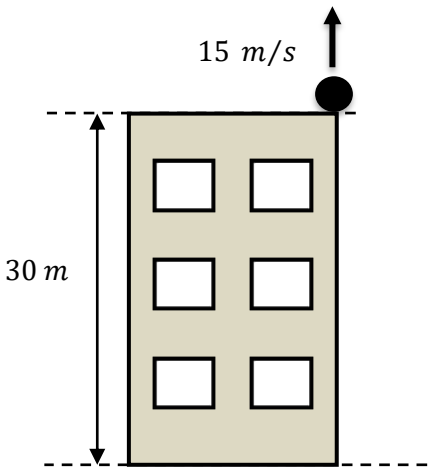
$$D_x = A_x + B_x = -Acos60^\circ + B = -(20)(0.5) + 30 = 20\,m$$

$$D_y = A_y + C_y = -Asin60^\circ + C = -(20)(0.86) + 40 = 22.8\,m$$

$$D = \sqrt{D_x^2 + D_y^2} = \sqrt{(20)^2 + (22.8)^2} \rightarrow D = 30.3\,m$$

$$v = \frac{displacement}{total\ time} = \frac{D}{\Delta t} = \frac{30.3}{2 \times 60} = 0.25\ m/s$$

P2. A student throws a ball upward at 15 m/s while standing on the edge of a building, so that the ball can fall to the base of the building 30 m below. What is the velocity of the ball 2 seconds before it reaches the ground? (4 points)



$$v_{ground}^2 = v_0^2 + 2g\Delta y \rightarrow v_{ground} = -28.5\ m/s$$

$$v_{ground} = v_0 + gt_{ground} \rightarrow t_{ground} = \frac{-28.5 - 15}{-9.8} = 4.44\,s$$

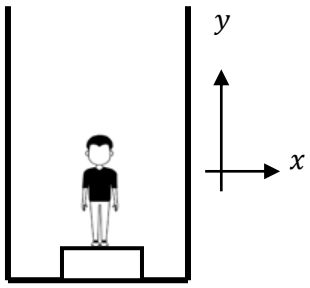
$$t = t_{ground} - 2 = 2.44\,s$$

$$v = v_0 + gt \rightarrow v = 15 + (-9.8) \times (2.44) = -8.9\ m/s$$

P3. A student stands on a scale in an elevator moving upward. Shortly before reaching the top floor the scale reading is 0.8 of his regular weight ($0.8mg$).

a) What is the direction of the elevator's acceleration? (1 points)

b) Find the magnitude of the acceleration. (2 points)



Direction of elevator's acceleration is downward.

$$F_N - mg = m(-a)$$

$$a = \frac{mg - F_N}{m} = \frac{mg - 0.8 \times mg}{m} = 0.2 \times g = 1.96\ m/s^2$$

P4: A box of mass $m = 8$ kg is sliding downward on a rough surface of an incline while a force parallel to the surface of the incline with magnitude $F = 15$ N is acting on it as shown. The kinetic coefficient of friction between the box and the incline's surface is $\mu_k = 0.2$.

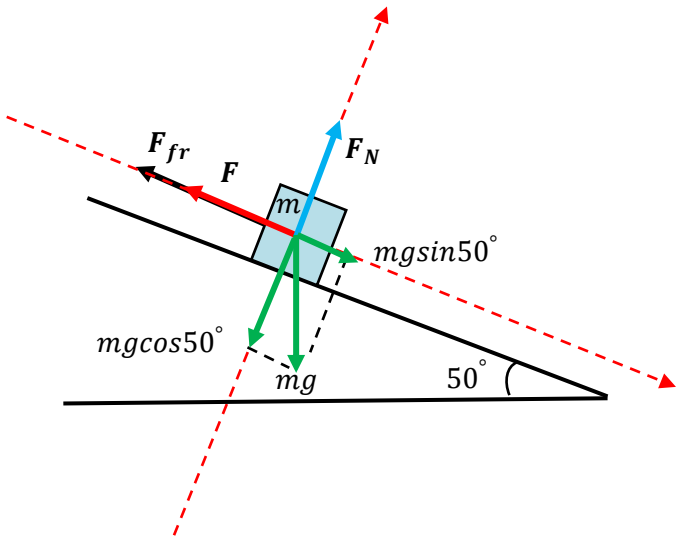
a) Draw the free body diagram for the box. (1 point)

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

$$F_{fr} = \mu_k \times F_N = \mu_k \times mgcos50^\circ \rightarrow F_{fr} = 10.1\ N$$

$$mgsin50^\circ - F_{fr} - F = ma \rightarrow a = \frac{mgsin50^\circ - F_{fr} - F}{m}$$

$$a = \frac{(8)(9.8)(0.76) - 10.1 - 15}{8} = 4.3\ m/s^2$$



P5. A cylinder of radius R is fixed to the ground. A box of mass m = 250 g is sliding inside the surface of the cylinder, as shown. The minimum speed of the box at the top of the cylinder (point A) to continue moving in a circular path without falling, is $v_A = 3$ m/s.

a) Find the radius R of the cylinder. (2 points)

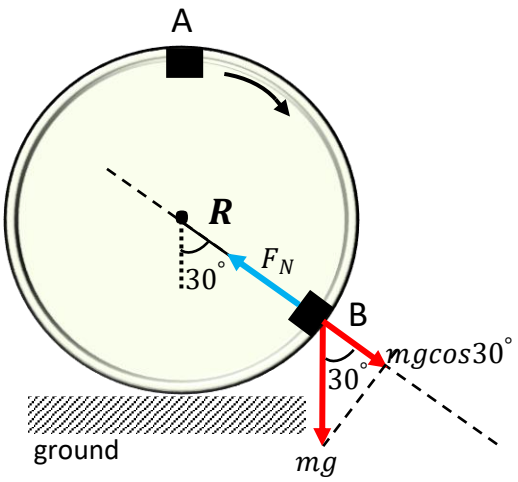
b) The normal force at point B is $F_N = 10$ N. Find the speed of the box at point B. (2 points)

$$F_N + mg = \frac{mv_A^2}{R} \rightarrow 0 + mg = \frac{mv_A^2}{R}$$

$$R = \frac{v_A^2}{g} = \frac{(3)^2}{9.8} = 0.9\ m$$

$$F_N - mgcos30^\circ = \frac{mv_B^2}{R} \rightarrow v_B^2 = \frac{R \times (F_N - mgcos30^\circ)}{m}$$

$$v = \sqrt{\frac{0.9 \times (10 - 0.25 \times 9.8 \times 0.86)}{0.25}} = 5.3\ m/s$$



P6. A spring with stiffness constant $k = 150$ N/m is compressed for 50 cm from its natural length and has a box of mass $m = 3$ kg at one end as shown. The box is released from rest (point A) and moves along the horizontal surface and enters (point B) a semicircular loop of radius R. Ignore friction forces.

a) Find the radius of the loop so that the box passes point C at 2 m/s. (2 points)

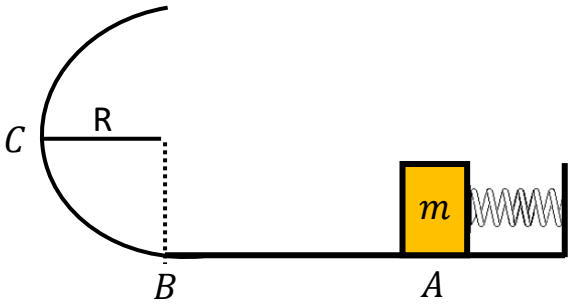
b) Find the work done by force of gravity on the box from point B to point C. (2 points)

$$E_A = E_B \rightarrow 0 + \frac{1}{2}kx^2 = \frac{1}{2}mv_C^2 + mgR$$

$$R = \frac{kx^2 - mv_C^2}{2mg} = 0.4\ m$$

$$W_{mg} = -\Delta PE_G = -\left[(PE)_C - (PE)_B\right] = -mgR$$

$$W_{mg} = -11.7\ J$$



P7. A car of mass $m = 1500$ kg moving on a horizontal road accelerates uniformly from rest to a speed of 21 m/s in 14 seconds over a distance of 147 m. The average force of friction is 2940 N. Calculate the average power of the car's engine. (4 points)

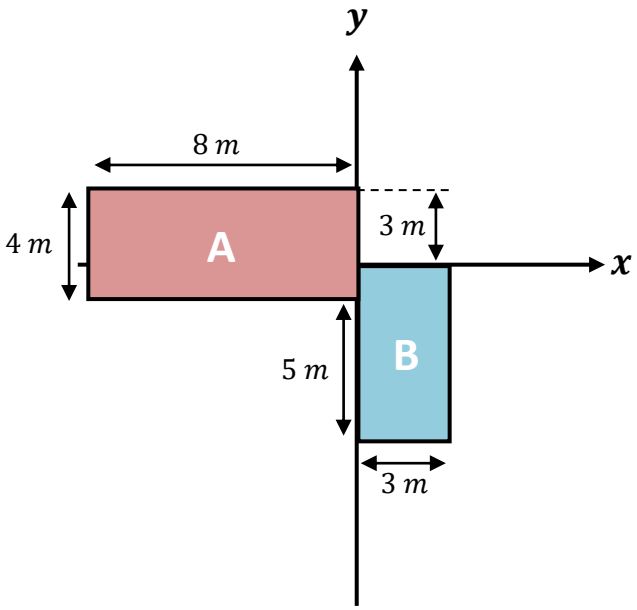
$$W_{engine} + W_{fr} = \frac{1}{2}mv^2 \rightarrow W_{engine} - F_{fr} \times d = \frac{1}{2}mv^2$$

$$W_{engine} = F_{fr} \times d + \frac{1}{2}mv^2 = 762930\ J$$

$$\overline{P}_{engine} = \frac{W_{engine}}{t} = 54495\ W$$

P8. Two rectangular blocks of mass $m_A = 5$ kg, $m_B = 2$ kg are shown. Find the position of the center of mass (CM) of the system. (4 points)

Block	X	Y
A	-4	1
B	1.5	-3



$$X_{CM} = \frac{m_A x_A + m_B x_B}{m_A + m_B} = \frac{(5) \times (-4) + (2) \times (1.5)}{5 + 2}$$

$$X_{CM} = -2.4\ m$$

$$Y_{CM} = \frac{m_A y_A + m_B y_B}{m_A + m_B} = \frac{(5) \times (1) + (2) \times (-3)}{5 + 2}$$

$$Y_{CM} = -0.14\ m$$

P9. A car's tire with radius $r = 30$ cm makes 85 revolutions while the car's speed increases uniformly from rest to 108 km/h. Find the angular acceleration of the car's tire. (4 points)

$$v_0 = 0 \rightarrow \omega_0 = 0\ rad/s$$

$$v = \frac{108}{3.6} = 30\ m/s \rightarrow \omega = \frac{v}{r} = \frac{30}{0.3} = 100\ rad/s$$

$$\Delta\theta = 85 \times 2\pi = 533.8\, rad$$

$$\omega^2 = \omega_0^2 + 2\alpha\Delta\theta \rightarrow \alpha = \frac{\omega^2 - \omega_0^2}{2\Delta\theta} = 9.36\ rad/s^2$$

P10. A beam of mass $m = 60$ kg and length L leans against a frictionless wall at angle of $\theta = 60^\circ$ to the rough surface of the ground as shown. The beam is in static equilibrium.

a) Find the normal force F_N from the ground to the beam. (1 point)
b) Find the force F_W that the wall exerts on the beam. (3 points)
c) Find the force of friction between the beam and ground. (1 point)

$$\sum F_y = 0 \rightarrow F_N = mg \rightarrow F_N = 588\ N$$

$$r_{\perp(F_W)} = L \times sin\theta$$

$$\sum \tau = 0 \rightarrow \tau_{mg} = \tau_{F_W} \rightarrow \frac{L}{2} \times cos\theta \times mg = L \times sin\theta \times F_W$$

$$F_W = \frac{mg \times cos\theta}{2sin\theta} \rightarrow F_W = 170\ \text{N}$$

$$\sum F_x = 0 \rightarrow F_{fr} = F_W \rightarrow F_{fr} = 170\ \text{N}$$