Kuwait University Physics Department

Physics 121

Midterm I Exam
Fall Semester (2023-2024)

October 28, 2023
Time: 15:00 – 16:30

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

Student's Number: ….…… Section No: ……

Instructors: Drs. Abdullah, Afrousheh, Alotaibi, Hadipour, Kokkalis, Razee, Zaman

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Important Instructions to the Students:

1. Answer all questions and problems.
2. Full mark = 26 points as arranged in the table below.
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

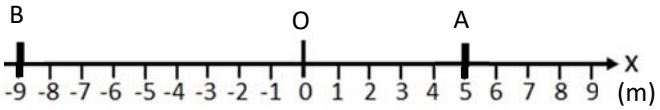
#	P1	P2	P3	P4	P5	P6	P7	Total
Pts	4	4	4	4	3	4	3	26

GOOD LUCK

P1. A car travels from the origin (O) to point A, with **constant velocity** of magnitude $v_1 = 3$ m/s. Then, it travels back to point B with **constant velocity** $\overrightarrow{v_2}$. The **average speed** of the car for the whole trip (from O to A and back to B) is 2 m/s.

a) Find the time it took the car to move from A to B? **(3 points)**

b) Find the velocity $\overrightarrow{v_2}$ of the car travelling from A to B? **(1 point)**



$$Average\ speed = \frac{total\ distance}{total\ time} \rightarrow 2 = \frac{10+9}{t} \rightarrow t = 9.5\ s$$

$$v_1 = \frac{x_A - x_O}{t_1} \rightarrow t_1 = \frac{x_A}{v_1} = \frac{5}{3} = 1.7\ s$$

$$t = t_1 + t_2 \rightarrow t_2 = t - t_1 = 9.5 - 1.7 = 7.8\ s$$

$$v_2 = \frac{x_B - x_A}{t_2} = \frac{-9-5}{7.8} = -1.8\ {}^{m}/_{s}$$

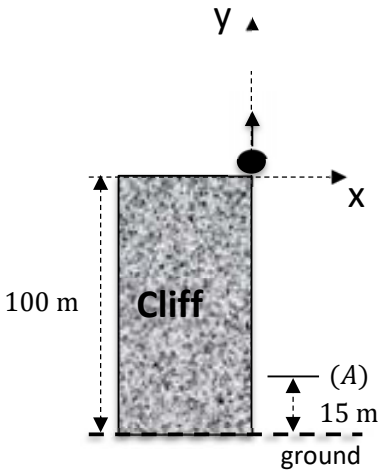
P2. A student throws a ball upward with initial velocity 25 m/s while standing on the edge of a cliff, so that the ball can fall to the base of the cliff 100 m below. **Ignore air resistance during the motion.**

a) Find the velocity of the ball when it is 15 m above the ground (point A)? **(2 points)**

b) How long does it take for the ball to reach the ground? **(2 points)**

$$v^2 = v_0^2 + 2a(y - y_0) \rightarrow v^2 = (25)^2 + 2(-9.8)(-85 - 0) = 2291$$

$$v^2 = 2291 \rightarrow v = \pm 47.9\ {}^{m}/_{s} \rightarrow v = -47.9\ {}^{m}/_{s}$$



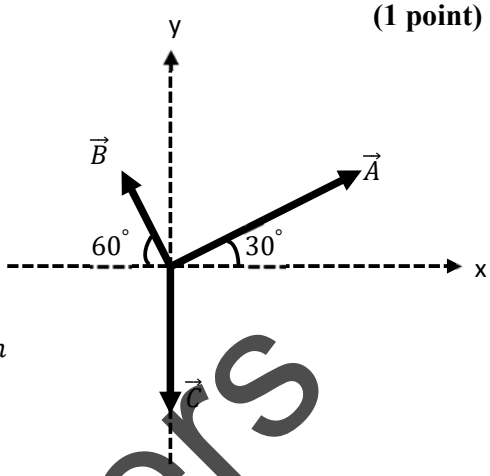
$$y = y_0 + v_0 t + \frac{1}{2}at^2 \rightarrow -100 = 0 + (25)t + \frac{1}{2}(-9.8)t^2$$

$$4.9t^2 - 25t - 100 = 0 \rightarrow t = \frac{25 \pm \sqrt{(-25)^2 - 4(4.9)(-100)}}{2(4.9)} \rightarrow t = 7.74\ s$$

P3. Three vectors with magnitudes, $A = 5$ m, $B = 2$ m, and $C = 3$ m are shown below. Vector $\vec{R}$ is given by $\vec{R} = 2\vec{A} - \vec{B} + 3\vec{C}$.

a) Find the magnitude of vector $\vec{R}$. **(3 points)**

b) Find the direction of $\vec{R}$, with respect to the positive *x-axis*. **(1 point)**



$$R_x = 2A_x - B_x + 3C_x = 2(A.cos30^\circ) - (-B.cos60^\circ) + 3(0) = 9.7\ m$$

$$R_y = 2A_y - B_y + 3C_y = 2(A.sin30^\circ) - (B.sin60^\circ) + 3(-C) = -5.7\ m$$

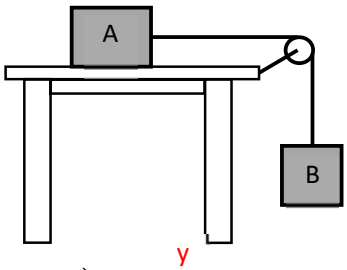
$$R = \sqrt{R_x^2 + R_y^2} = \sqrt{(9.7)^2 + (-5.7)^2} = 11.3\ m$$

$$\tan\theta = \frac{R_y}{R_x} = \frac{-5.7}{9.7} = -0.59 \rightarrow \theta = -30.5^\circ$$

P4. Box A ($m_A = 8$ kg) lies on a rough table ($\mu_k = 0.2$), and is connected to a box B (m_B) by a lightweight cord as shown. When box B is released box A moves to the east with **uniform acceleration** $a = 2$ m/s^2.

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

b) Find the mass of box B (m_B). **(2 points)**

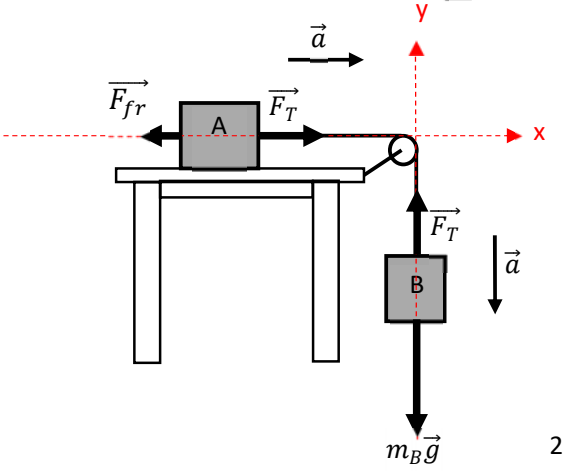


Box A:

$$F_{fr} = \mu_k m_A g = (0.2)(8)(9.8) = 15.7\ N$$

$$\sum \vec{F_x} = m_A\vec{a} \rightarrow F_T - F_{fr} = m_A a$$

$$\rightarrow F_T = m_A a + F_{fr} = (8)(2) + 15.68 = 31.7\ N$$



Box B:

$$\sum \vec{F_y} = m_B\vec{a} \rightarrow F_T - m_B g = m_B(-a)$$

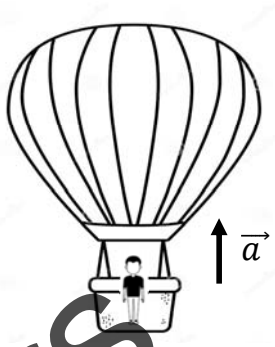
$$F_T = m_B(g - a) \rightarrow m_B = \frac{F_T}{g - a} = \frac{31.7}{9.8 - 2} = 4.1\ kg$$

P5. A $68-$ kg student is standing on a scale inside an air balloon. When the balloon **accelerates upward**, the scale shows 75 kg.

a) Find the apparent weight (in N) of the student. **(1 point)**

b) Find the magnitude of balloon's acceleration? **(2 points)**

$F_N = m_{scale}\, g = 75 \times 9.8 = 735\ N$

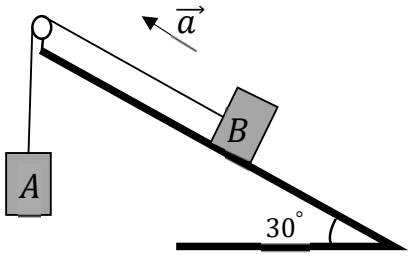


Taking positive y-direction to be upward

$$\sum \vec{F}_y = m\vec{a}_y \rightarrow F_N - mg = ma$$

$$a = \frac{F_N - mg}{m} = \frac{735\ - 666.4}{68} = 1.0\ {}^{m}/_{s^2}$$

P6. Two boxes A and B with equal mass ($m_A = m_B = m$) are connected by a lightweight cord as shown. **Find their acceleration** when the system is released from rest. **Ignore any force of friction**. **(4 points)**



Box A: Taking positive y-direction to be upward

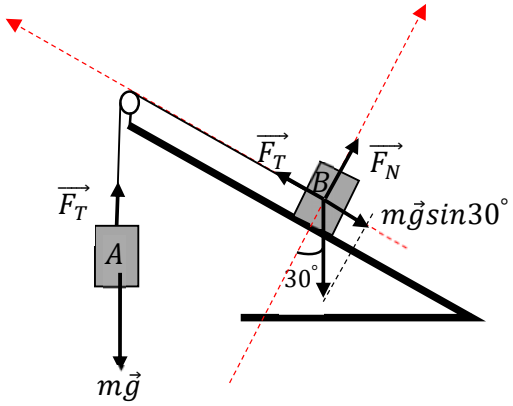
$$\sum \vec{F}_y = m\vec{a}_y \rightarrow F_T - mg = m(-a) \rightarrow F_T = m(g - a) \quad (1)$$

Box B: Taking the positive x-direction as shown

$$\sum \vec{F}_x = m\vec{a}_x \rightarrow F_T - mgsin30^\circ = m\,a \rightarrow F_T = m(gsin30^\circ + a) \quad (2)$$

$$(1)\ \&\ (2) \rightarrow m(g - a) = m(gsin30^\circ + a) \rightarrow a = \frac{g(1 - sin30^\circ)}{2}$$

$$a = 2.45\ {}^{m}/_{s^2}$$



P7. A centripetal force of magnitude 4 N acts on a 0.2 kg ball and keeps it in a horizontal uniform circular motion of radius $R = 15$ cm.

a) Find the magnitude of the linear velocity of the ball. **(2 points)**

b) Find the period of the circular motion. **(1 point)**

$$a_R = \frac{F_c}{m} = \frac{4}{0.2} = 20\ m/s^2$$

$$a_R = \frac{v^2}{R} \rightarrow v = \sqrt{a_R R} = 1.7\ m/s$$

$$v = \frac{2\pi R}{T} \rightarrow T = \frac{2\pi R}{v} = 0.6\ s$$