Kuwait University Department of Physics

General Physics I for Biological Sciences (Phy 121)

First Midterm Examination

Spring Semester 2024-2025

March 11, 2025
Time: 8:30 PM to 10:00 PM

Instructors: Dr. Abdulmuhsen, Dr. Al-Failakawi, Dr. Al-Otaibi, Dr. Burahmah, Dr. Hadipour, Dr. Kokkalis and Dr. Razee

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Solution

Instructions to the Students:

- Answer all the questions. Show all your working in this booklet.
- All communication devices must be switched off and placed in your bag or deposited with the invigilator in charge. Anyone found using a communication device will be disqualified.
- Programmable calculators, which can store equations, are not allowed. You may use a non-programmable calculator.
- Cheating incidents will be processed according to the University rules.
- **Use SI units**.
- **Take $g = 9.8$ m/s^2**.

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1. A car travelling at 90 km/h breaks and decelerates uniformly at a rate of 1.3 m/s^2 to stop.

   (a) Find the time taken to stop. **2 point**

   (b) Find the distance travelled by the car after breaking. **2 points**

Solution: The initial speed in SI unit is

$$v_0 = \frac{90}{3.6} = 25 \text{ m/s}$$

Time taken to stop is

$$t = \frac{v - v_0}{a} = \frac{0 - 25}{-1.3} = 19.2 \text{ s}$$

The distance travelled during this time is

$$x - x_0 = \overline{v}t = \frac{1}{2}(25 + 0) \times 19.2 = 240 \text{ m}$$

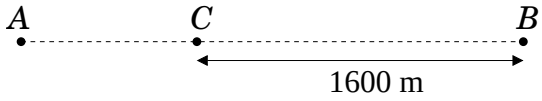
OR

$$x - x_0 = \frac{v^2 - v_0^2}{2a} = \frac{-25^2}{2 \times (-1.3)} = 240 \text{ m}$$

OR

$$x - x_0 = v_0 t + \frac{1}{2}at^2 = 25 \times 19.2 + \frac{1}{2}(-1.3) \times (19.2)^2 = 240 \text{ m}$$

2. Starting from rest at A, Othman accelerates at 0.08 m/s^2 to reach B in 4 minutes. He takes a rest at B for 5 minutes, then travels 1600 m to C in 6 minutes (see the figure).



   (a) Find his average **speed** of the whole journey. **2 points**

   (b) Find his average **velocity** of the whole journey. **2 points**

Solution: The distance AB is

$$AB = \frac{1}{2}at^2 = \frac{1}{2} \times 0.08 \times (4 \times 60)^2 = 2304 \text{ m}$$

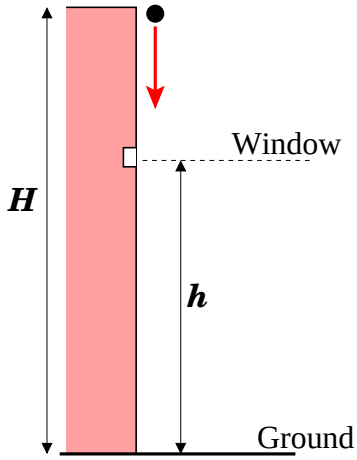
Total distance travelled: $AB + BC = 3904$ m

Average speed: $$\frac{3904}{(4 + 5 + 6) \times 60} = 4.34 \text{ m/s}$$

Total displacement: $AC = AB - BC = +704$ m

Average velocity: $$\frac{+704}{(4 + 5 + 6) \times 60} = +0.78 \text{ m/s}$$

3. A stone is thrown **vertically downward** with speed 5 m/s from the edge of the roof of a building. It **passes a window** after 3 s and **lands on the ground** after 6 s. Ignore air resistance.



   (a) Find the height (H) of the building. **2 points**

   (b) Find the height (h) of the position of the window from the ground. **2 points**

Solution: We choose the positive $x-$axis upward.

(a) We have

$$x_0 = H \text{ (height of the building, unknown)}$$

$x = 0$ (Ground), $v_0 = -5$ m/s, $a = -9.8$ m/s^2, $t = 6$ s

We use

$$x = x_0 + v_0 t + \frac{1}{2}at^2 \implies 0 = H - 5 \times 6 + \frac{1}{2}(-9.8) \times 6^2$$
$$\implies H = 206.4 \text{ m}$$

(b) We have

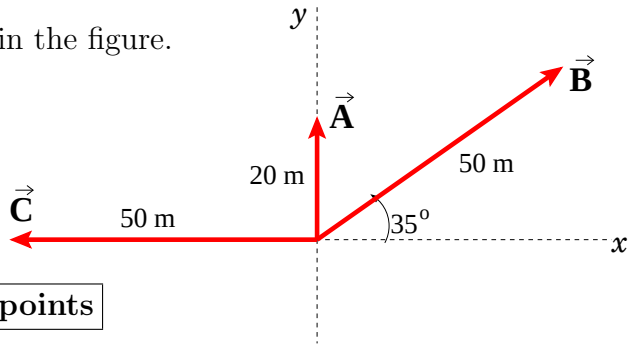
$$x_0 = 206.4 \text{ m}, \quad x = h \text{ (position of the window, unknown)}$$
$$v_0 = -5 \text{ m/s}, \quad a = -9.8 \text{ m/s}^2, \quad t = 3 \text{ s}$$

We use

$$x = x_0 + v_0 t + \frac{1}{2}at^2 \implies h = 206.4 - 5 \times 3 + \frac{1}{2}(-9.8) \times 3^2$$
$$\implies h = 147.3 \text{ m}$$

4. Three vectors $\vec{\mathbf{A}}$, $\vec{\mathbf{B}}$ and $\vec{\mathbf{C}}$ are shown in the figure. The vector

$$\vec{\mathbf{D}} = \vec{\mathbf{B}} + \vec{\mathbf{C}} - 2\vec{\mathbf{A}}$$



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

   (b) Find the angle between the $+x$-axis and the vector $\vec{\mathbf{D}}$. **1 point**

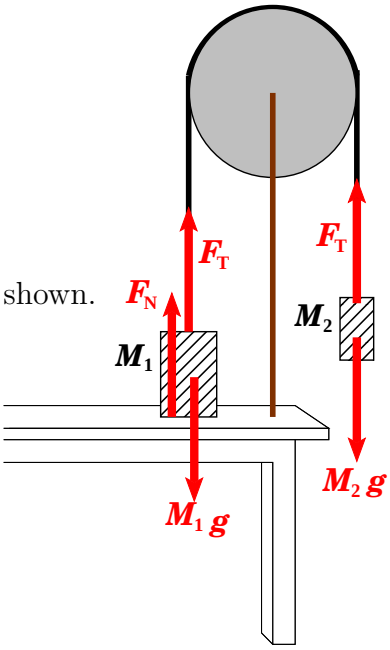
Solution: We have

$$D_x = B_x + C_x - 2A_x = 50 \cos 35^o - 50 + 0 = -9.04 \text{ m}$$
$$D_y = B_y + C_y - 2A_y = 50 \sin 35^o - 0 - 2 \times 20 = -11.32 \text{ m}$$
$$D = \sqrt{D_x^2 + D_y^2} = 14.5 \text{ m}$$
$$\theta = \tan^{-1}\left(\frac{-11.32}{-9.04}\right) + 180^o = 231.4^o$$

5. The box of mass $M_1 = 5$ kg is **at rest** on a table and is connected to the box of mass $M_2 = 3$ kg by a massless rope going over a massless and frictionless pulley as shown.

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

   (b) Find the normal force exerted by the table on the box of mass M_1. **1 point**



Solution: The free-body diagrams for M_1 and M_2 are shown.

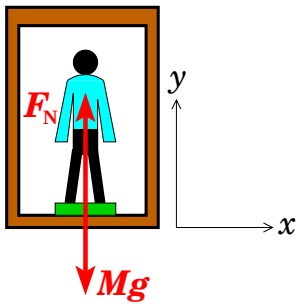
For box M_2:

$$F_T - M_2 g = 0 \implies F_T = 29.4 \text{ N}$$

For box M_1:

$$F_T + F_N - M_1 g = 0 \implies F_N = 19.6 \text{ N}$$

6. A 60 kg person is standing on a scale inside a lift that **accelerates downward** at 3 m/s^2. What does the scale show in kg? **3 points**



Solution: Looking at the free-body diagram, the Newton's second law implies,

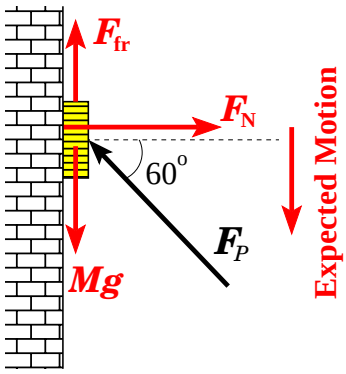
$$F_N - Mg = -Ma$$

$$\implies F_N = Mg - Ma = 408N$$

Then the reading in the scale is

$$\text{Reading } = \frac{F_N}{g} = 41.6 \text{ kg}$$

7. A book of mass 0.8 kg is pressed against a vertical wall to prevent it from falling down by applying a force of magnitude F_P at angle 60^o with the horizontal as shown. The coefficient of static friction between the wall and the book is $\mu_s = 0.52$. Find the minimum value of F_P that is required so that the book **does not slide down** the wall. **4 points**



Solution: The free-body diagram for the book is shown: (i) The normal force F_N is normal to the contact surface, (ii) The force, Mg (due to gravity) is downward and (iii) since the expected motion (if F_P is not sufficient) is downward, the force of friction F_{fr} is upward.

We choose the positive x-axis to the right and the positive y-axis upward. Then

$$x-\text{direction:} \qquad -F_P\ \cos 60^o + F_N = 0 \implies F_N = F_P\ \cos 60^o$$

$$y-\text{direction:} \qquad +F_P\ \sin 60^o + F_{fr} - Mg = 0$$

$$\implies F_P\,(\sin 60^o + \mu_s\ \cos 60^o) = Mg$$

$$\implies F_P = \frac{Mg}{\sin 60^o + \mu_s\ \cos 60^o} = 6.96\ \text{N}$$