Kuwait University Department of Physics

جامعة الكويت
KUWAIT UNIVERSITY

General Physics I for Biological Sciences (Phy 121)

First Midterm Examination

Summer Semester, 2022-2023

June 24, 2023
Time: 2:00 PM to 3:30 PM

Instructors: Drs. Abdulmuhsen, Al-Otaibi, Lajko, Kokkalis and 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**.

For use by instructors only

Problem #	P1	P2	P3	P4	P5	P6	P7	Total
Max. Marks	**4**	**4**	**4**	**4**	**4**	**3**	**5**	**28**
Marks								

1. Abdullah drives 50 km from his home to the university at a constant speed of 80 km/h, spends 2 hours at the university and returns home at a constant speed of 16 m/s. Calculate the average speed (in m/s) of Abdullah for the entire trip. **4 points**

Solution: For the **outbound** journey,

$$t_1 = \frac{50}{80} = 0.625 \text{ hours} = 2250 \text{ s}$$

$$\text{At the University:} \qquad t_2 = 2 \text{ hours} = 7200 \text{ s}$$

For the **return** journey,

$$t_3 = \frac{50000}{16} = 3125 \text{ s}$$

$$\text{Average speed } = \frac{50000 \times 2}{t_1 + t_2 + t_3} = 7.95 \text{ m/s}$$

2. A stone is **dropped** from the roof of a high-rise building at $t = 0$. The stone landed on the ground at $t = 8.5$ s. Ignore air resistance.

   (a) How high is the building? **2 points**

   (b) Sarah is sitting 200 m above the ground at the window of her flat. At what **speed** the stone passed Sarah? **2 points**

Solution:

(a) We have $x_0 = h$, $v_0 = 0$ (dropped), $t = 8.5$ s, $a = -9.8$ m/s^2, $x = 0$. Then

$$0 - h = \frac{1}{2}(-9.8)(8.5)^2 \implies h = 354 \text{ m}$$

(b) We have $x_0 = 354$ m, $v_0 = 0$, $a = -9.8$ m/s^2, $x = 200$ m. Then

$$v^2 = v_0^2 + 2a(x - x_0) \implies v^2 = 3019 \implies v = 54.9 \text{ m/s}$$

3. A car starting from rest accelrates at 4 m/s^2 for 5 s, and then accelerates at 3 m/s^2 for further 5 s. How far the car has travelled? **4 points**

Solution: For the first 5 s, the distance travelled is: $x_1 = \frac{1}{2}at^2 = 50$ m

The speed at the end of first 5 s is: $v_1 = at = 20$ m/s

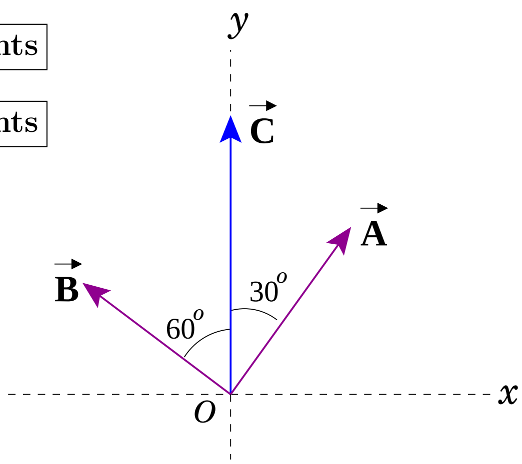
The distance travelled in the next 5 s is: $x_2 = v_1 t + \frac{1}{2}at^2 = 137.5$ m

Total distance travelled is: $x = x_1 + x_2 = 187.5$ m

4. Three vectors $\vec{\mathbf{A}}$, $\vec{\mathbf{B}}$ and $\vec{\mathbf{C}}$ are shown in the figure below. $\vec{\mathbf{C}} = \vec{\mathbf{A}} + \vec{\mathbf{B}}$ and $\vec{\mathbf{C}}$ is along the y-axis. The magnitude of $\vec{\mathbf{A}}$ is 45.0 units.

   (a) Find the magnitude of $\vec{\mathbf{B}}$. **2 points**

   (b) Find the magnitude of $\vec{\mathbf{C}}$. **2 points**



Solution:

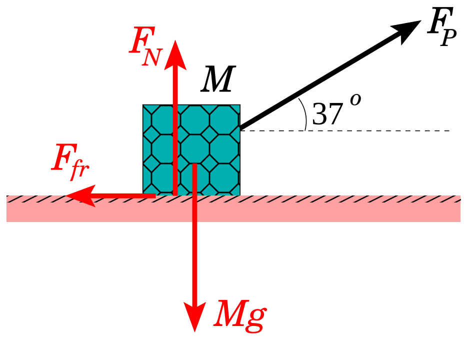
$$C_x = A_x + B_x \implies 0 = A\ \cos 60^o + B\ \cos 150^o$$

$$\implies B = -\frac{A\ \cos 60^o}{\cos 150^o} \implies B = 26 \text{ units}$$

$$C = C_y = A_y + B_y \implies C = A\ \sin 60^o + B\ \sin 150^o = 39 + 13$$

$$\implies C = 52 \text{ units}$$

5. A 12-kg box is being pulled with a force of magnitude $F_p = 80$ N on a rough horizontal surface as shown. The coefficient of kinetic friction between the box and the surface is $\mu_k = 0.3$. Calculate the acceleration of the box. **4 points**



Solution: We choose the positive x-axis to the right and the y-axis perpendicular to the surface. The free-body diagram for the box is shown.

Along the $y-$axis:

$$F_N - Mg + F_p\ \sin 37^o = 0 \implies F_N = Mg - F_p\ \sin 37^o = 69.4\ \text{N}$$

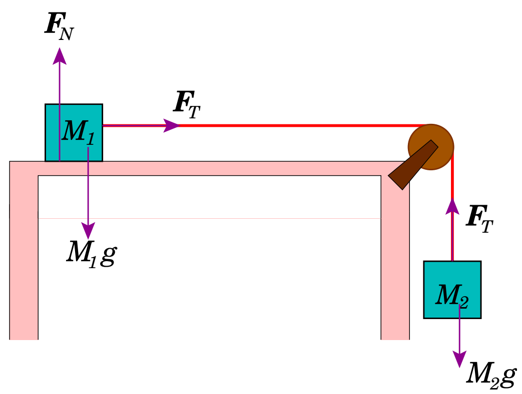
Along the $x-$axis:

$$F_p\ \cos 37^o - \mu_k F_N = Ma \implies a = \frac{F_p\ \cos 37^o - \mu_k F_N}{M} = 3.6\ \text{m/s}^2$$

6. A box of mass $M_1 = 5$ kg is on a horizontal frictionless table. It is connected by a massless string over a massless pulley to the box of mass M_2 (unknown) as shown. When they are released, the acceleration of box M_2 is $a = 2.0\ \text{m/s}^2$.

   (a) Find the tension F_T in the string. **1 point**

   (b) Find the mass M_2. **2 points**



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

For box M_1:

$$F_T = M_1 a \implies F_T = 10\ \text{N}$$

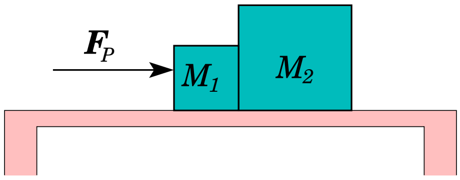
For box M_2:

$$F_T - M_2 g = -M_2 a \implies F_T = M_2(g - a) \implies M_2 = \frac{F_T}{g - a} = 1.3\ \text{kg}$$

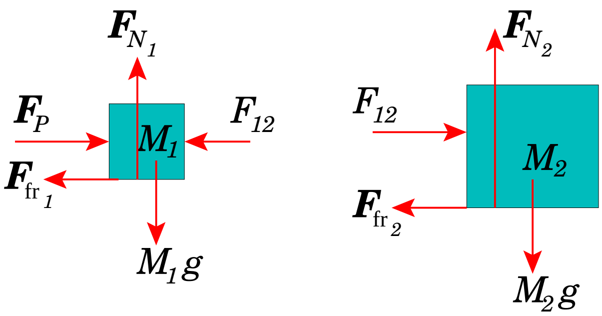
7. Two boxes of mass $M_1 = 10$ kg and $M_2 = 12$ kg are in contact, and are being pushed on a horizontal table by a force $F_p = 240$ N as shown. The coefficient of kinetic friction between the boxes and the table is $\mu_k = 0.3$.

   (a) Find the acceleration of the boxes. **3 points**

   (b) Find the magnitude of the force exerted by the box 1 on the box 2. **2 points**



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



For box M_1:

$$F_p - F_{12} - \mu_k M_1 g = M_1 a \qquad (1)$$

For box M_2:

$$F_{12} - \mu_k M_2 g = M_2 a \qquad (2)$$

Adding (1) and (2), we get

$$F_p - \mu_k (M_1 + M_2) g = (M_1 + M_2) a$$

$$\Longrightarrow \quad a = \frac{F_p - \mu_k (M_1 + M_2) g}{M_1 + M_2} = 8.0 \text{ m/s}^2$$

Then Eq. (2)

$$F_{12} = M_2 a + \mu_k M_2 g = 131.0 \text{ N}$$