Kuwait University Physics Department

جامعة الكويت
KUWAIT UNIVERSITY

Physics 121

First Midterm Exam
Summer Semester (2024-2025)

July 8, 2025
Time: 18:30 – 20:00

Student's Name: ……. Serial Number: ……

Student's Number: …….. Section: ……

Instructors: Drs. Alfailakawi, Alotaibi, Hadipour, 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	Total
Pts	5	4	5	4	3	4	4	29

GOOD LUCK

P1. Starting from rest at home, you accelerate uniformly at 0.8 m/s^2 to reach a speed of 108 km/h and then you drive at a constant speed of 108 km/h to reach the University. Your total driving time was 5 minutes. How far is the University from your house? **(5 points)**

$$v = \frac{108}{3.6} = 30\ \frac{\text{m}}{\text{s}}$$

$$v = v_0 + at \rightarrow 30 = 0 + 0.8 \times t \rightarrow t = 37.5\ \text{s}$$

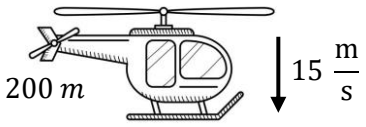
$$x_1 = \frac{v + v_0}{2} \times t \rightarrow x_1 = 562.5\ m$$

$$t_2 = t - t_1 = (5 \times 60) - 37.5 = 262.5\ s$$

$$x_2 = v \times t_2 = 7875\ m$$

$$x = x_1 + x_2 = 8437\ m$$

P2. A helicopter is descending vertically at a constant speed of 15 m/s. When it is at a height of 200 m, a package is dropped from the helicopter.
a. Find the time when the package lands on the ground. **(2 points)**
b. The helicopter continues to descend at the same speed. Find the position of the helicopter above the ground when the package lands on the ground. **(2 points)**



ground

For the package:

$$v^2 = v_0^2 + 2g(y - y_0) \rightarrow v^2 = (-15)^2 + 2g(0 - 200) \rightarrow v = -64.4\ \frac{m}{s}$$

$$v = v_0 + gt \rightarrow t = \frac{v - v_0}{g} = 5.04\ s$$

For the helicopter:

$$y = y_0 + v_0 t$$

$$y = 200 + (-15) \times (5.04) = 124.\ 4\ m$$

P3. A hiker walks 4.0 km due north, then 3.0 km due east, and finally 2.0 km at an angle of 30° north of east, as shown in the figure. This walk took about 45 minutes.

a. Calculate the magnitude of the displacement. **(3 points)**

b. What is the average speed and average velocity of this hiker? **(2 point)**

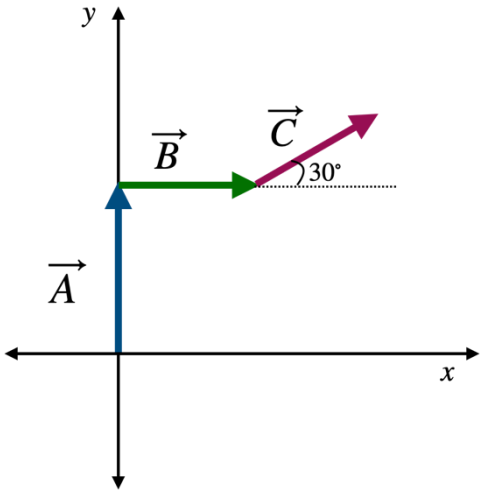
$A_x = 0, A_y = 4.0$ km

$B_x = 3.0$ km, $B_y = 0$

$C_x = 2.0\cos 30° = 1.73$ km, $C_y = 2.0 \sin 30° = 1.0$ km

(a) $D_x = 4.73$ km, $D_y = 5.0$ km $D = \sqrt{D_x^2 + D_y^2} = 6.88$ km

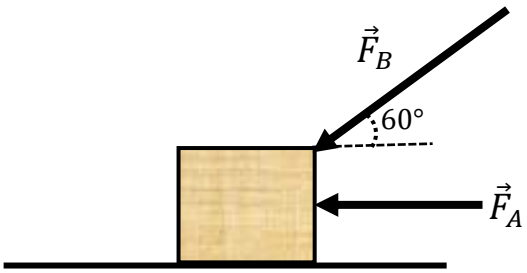
(b) $\bar{v} = \frac{D}{0.75\text{ h}} = 9.17 \frac{\text{km}}{\text{h}}$, $\bar{s} = \frac{4+3+2}{0.75\text{ h}} = 12$ km/h



P.4 A box with mass $m = 20\ kg$ is pushed on a frictionless surface by two forces $\vec{F_A}$ and $\vec{F_B}$ as shown. The magnitudes of forces are $F_A = 50\ N$ and $F_B = 70\ N$.

a. Determine the magnitude of the net force on the box. **(3points)**

b. What is the acceleration (size and direction) of the box? **(1 point)**

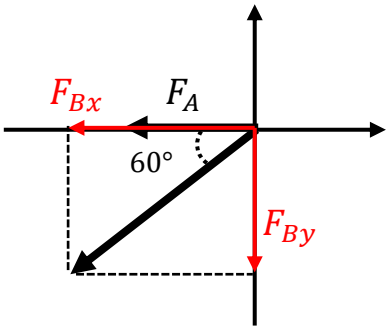


(a)

$F_{Ax} = -50.0\ N$

$F_{Bx} = -70\cos(60°) = -35.0\ N$

$F_x = F_{Ax} + F_{Bx} = (-50) + (-35) = -85$ N



(b)

$F_x = ma_x \rightarrow a_x = \frac{-85}{20} = -4.25\ \frac{\text{m}}{\text{s}^2}$

P5. A truck is accelerating forward at 3.0 $\mathrm{m/s^2}$. A 100 kg crate (box) is resting on the truck bed. The coefficient of static friction between the crate and the truck's bed is $\mu_s = 0.4$.

a. What is the maximum acceleration the truck can have before the crate starts to slide? **(2 points)**

b. Will the crate slide in this case? **(1 point)**

(a)

$$F_{fr} = \mu_s mg = 392 \text{ N}$$

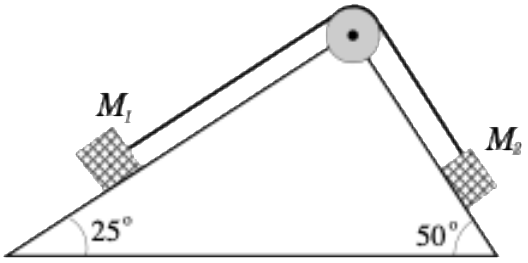
$$\vec{F} = m\vec{a} \rightarrow F_{fr} = ma \rightarrow a = \frac{F_{fr}}{m} = 3.92 \ \frac{\text{m}}{\text{s}^2}$$

(b) The crate does not slide since the truck's acceleration is less than 3.92 $\mathrm{m/s^2}$.

P6. Two boxes are connected to each other by a massless rope. They are kept at rest on a frictionless structure as shown below by putting the rope over a frictionless pulley. The mass M_1= 12 kg.

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

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



(a) Box 1 : $F_T - M_1 g \sin 25° = 0 \Longrightarrow F_T = M_1 g \sin 25° = 49.7$ N

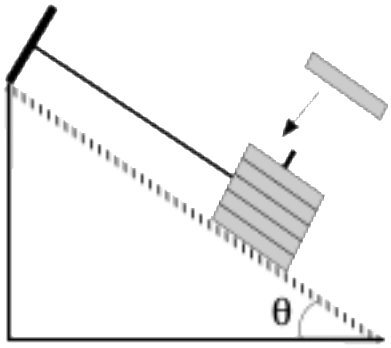
(b) Box 2 : $F_T - M_2 g \sin 50° = 0 \Longrightarrow M_2 = \frac{F_T}{g \sin 50°} = 6.6$ kg

P7. A box is kept on $\theta = 30°$ rough incline by a massless rope fixed to the top of the incline

as shown. The rope can withstand a maximum tension of F_T= 25 N. The mass of the box is gradually increased by adding small objects. The rope breaks when the mass of the box becomes M = 15 kg. Then the box accelerates down the incline at a rate of 2.7 m/s^2.

a. Find the coefficient of static friction **(μ_s)** between the box and the incline.
(2 points)

b. Find the coefficient of kinetic friction **(μ_k)** between the box and the incline.
(2 points)



(a) *y*-direction:

$F_N - Mg\cos\theta = 0 \Longrightarrow F_N = Mg\cos\theta = 127.3$ N

x-direction:

$Mg\sin\theta - \mu_s F_N - F_T = 0 \Longrightarrow \mu_s = \frac{Mg\sin\theta - F_T}{F_N} = 0.38$

(b)The rope is broken, so there is no tension:

x-direction:

$Mg\sin\theta - \mu_k F_N = Ma \Longrightarrow \mu_k = \frac{Mg\sin\theta - Ma}{F_N} = 0.26$