Kuwait University Physics Department

Physics 121

Mid-Term Exam I
Spring Semester (2022-2023)

March 11, 2023
Time: 18:30 – 20:00

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

Student's Number: ……..…… Section No: ……

Instructors: Drs. Alotaibi, Hadipour, Kokkalis, Razee, Salameh, Zaman

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Important Instructions to the Students:

1. Answer all questions and problems.
2. Full mark = 29 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	3	5	4	5	29

GOOD LUCK

P1. A family is driving back home from holidays at a constant speed of 95 km/h for 180 km. It then begins to rain, and the car slows down to 65 km/h. The entire trip took 4.5 h of driving.

a. Find the total distance for the entire trip. **(2 points)**

b. Find the average speed for the entire trip. **(2 points)**

$d_1 = 180\ km, t_1 = \frac{180}{95} = 1.9\ h, t_2 = t_{total} - t_1 = 4.5 - 1.9 = 2.6\ h$ **(2 points)**

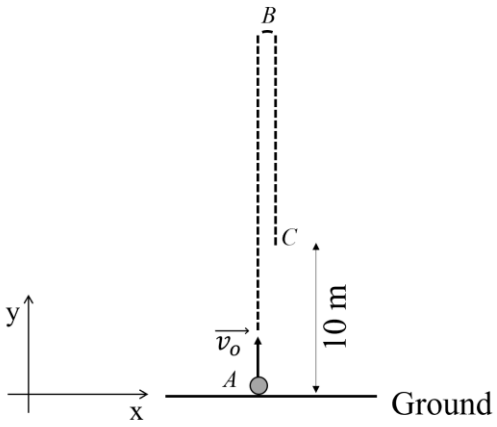
(a) $d_{total} = d_1 + d_2 = d_1 + s_2 \times t_2 = 180 + 65 \times 2.6 = 349\ km$ **(1 point)**

(b) $Average\ speed = \frac{total\ distance}{total\ time} = \frac{349}{4.5} = 77.5\frac{km}{h}$ **(1 point)**

P2. A rock is thrown vertically upward from the ground (point *A*), with an initial speed of 16 m/s. Ignore air resistance.

a. Find the time takes the rock to reach its maximum height (point *B*). **(2 points)**

b. Find the velocity of the rock at point *C*, located 10 m above ground. **(2 points)**



Taking positive *y*-axis upwards and origin at the ground:

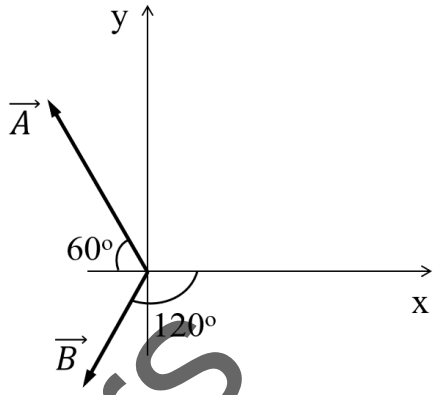
a. $v = v_0 + at \rightarrow 0 = 16 + (-9.8)t \rightarrow t = 1.6\ s$ **(2 points)**

b. $v^2 = v_0^2 + 2a(y - y_0) = 16^2 + 2(-9.8)(10 - 0) = 60 \rightarrow v = -7.7\frac{m}{s}$ **(2 points)**

P3. Vectors with magnitudes $A = 6.0$ units and $B = 4.0$ units, are shown. Vector $\overrightarrow{C}$ is given by the equation $\overrightarrow{C} = 2\overrightarrow{A} + \overrightarrow{B}$.

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

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



$C_x = 2A_x + B_x = (2)(-6)cos(60) - 4\ sin(30) = -8.0\ units$ **(1 point)**

$C_y = 2A_y + B_y = (2)(6)sin(60) - 4\ cos(30) = 6.9\ units$ **(1 point)**

$C = \sqrt{C_x^2 + C_y^2} = 10.6\ units$ **(1 point)**

$\theta' = \tan^{-1}\left|\frac{6.9}{8.0}\right| = 40.8 \rightarrow \theta = 180^o - 40.8^o = 139.2^o$ **(1 point)**

P4. A 50 kg hot air balloon can only move upwards due to a lifting force F_B. Two people are pulling it from the ground to prevent it from flying away, as shown in the figure.

a. Find the magnitude of force (F_2) required by the second person, to keep the balloon **at rest**. **(2 points)**

b. Find the upward acceleration of the balloon if both ropes break ($F_1 = F_2 = 0$ N). **(1 point)**

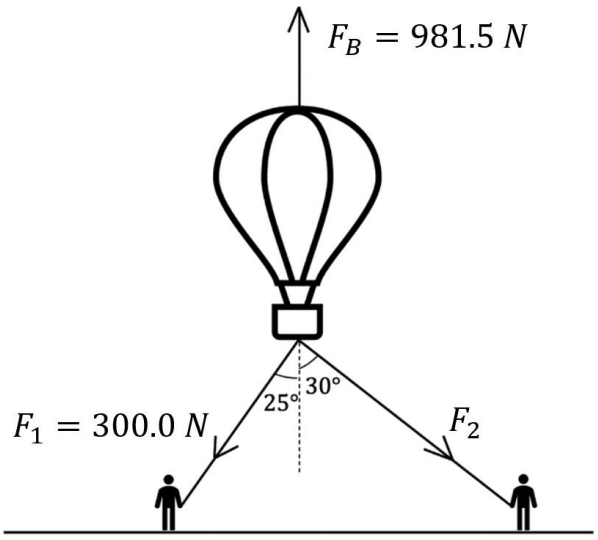
Taking positive *y-axis* upwards.

$F_B - mg - F_1 cos\theta_1 - F_2 cos\theta_2 = 0$ **(1 point)**

$F_2 = \frac{F_B - mg - F_1 cos\theta_1}{cos\theta_2} = 253.6\ N$ **(1 point)**

$F_B - mg = ma \rightarrow$

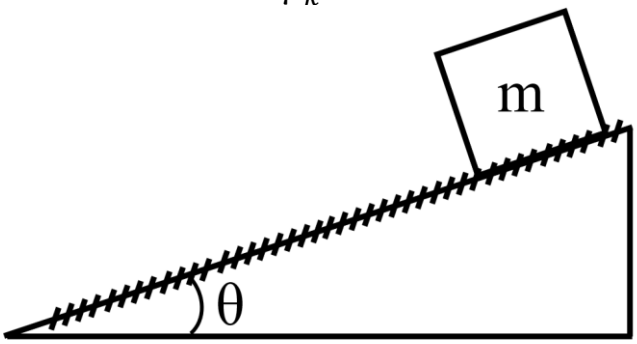
$a = \frac{F_B - mg}{m} = 9.83\ m/s^2$ **(1 point)**



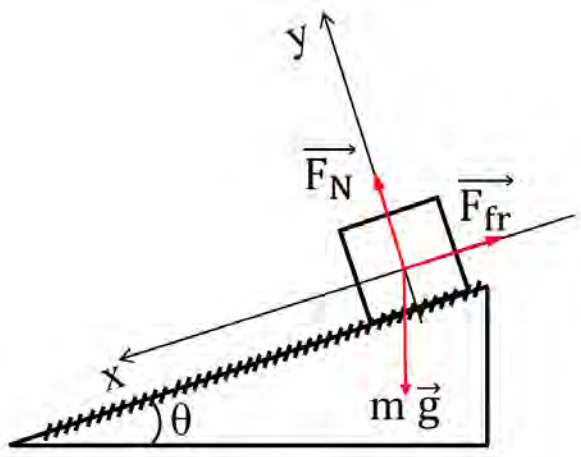
P5. A box of mass m is sliding down on a rough inclined surface of angle θ as shown. The coefficient of kinetic friction between the box and the surface is $\mu_k = 0.4$.

a. Draw the free body diagram for the mass m. **(1 point)**

b. Find the angle θ so that the box slides down with **constant speed**. **(4 points)**



a.



b.

m: y − axis: $F_N - mgcos\theta = 0 \rightarrow F_N = mgcos\theta$ (Eq. 1) **(1 point)**

m: x − axis: $-F_{fr}^k + mgsin\theta = ma \rightarrow \mu_k F_N - mgsin\theta = ma$ (Eq. 2) **(1 point)**

The box is moving with constant so $a = 0\ m/s^2$ (Eq. 3) **(1 point)**

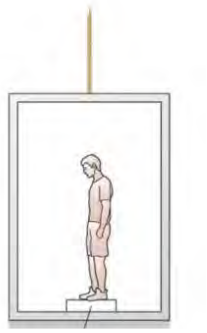
From Eqs. (1) & (2) & (3)

$\mu_k mgcos\theta - mgsin\theta = 0 \rightarrow tan\theta = \mu_k \rightarrow \theta = 22^o$ **(1 point)**

P6. A 60 kg student stands on a scale inside an elevator on the 4th floor of the science building. As the elevator is uniformly accelerated downwards, it takes 9.1 s to reach the ground floor. During this motion, the scale reads an apparent weight of 500 N.

a. Find the acceleration of the elevator during this motion. **(2 points)**

b. Starting from rest, find the average velocity of the elevator during this motion. **(2 points)**



Taking positive *y*-axis upward and origin at the 4th floor.

$F_N - mg = m(-a) \rightarrow 500 - 60 \times 9.8 = -60a \rightarrow$ **(1 point)**

$\rightarrow a = 1.47\ m/s^2$ **(1 point)**

$y = y_o + v_o t + \frac{1}{2}at^2 \rightarrow \Delta y = 0 + \frac{1}{2} \times (-1.47) \times t^2 \rightarrow \Delta y = -60.9\ m$ **(1 point)**

$\bar{v} = \frac{\Delta y}{\Delta t} \rightarrow \bar{v} = -6.7\ m/s$ **(1 point)**

Or

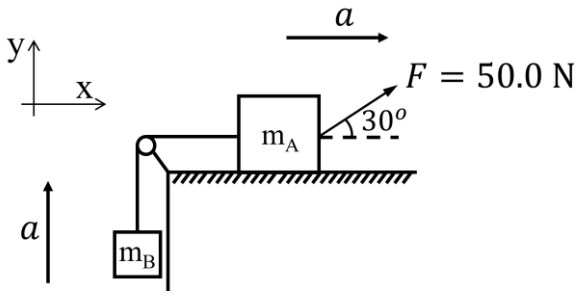
$v = v_o + at \rightarrow v = 0 + (-1.47) \times 9.1 \rightarrow v = -13.4\ m/s$ **(1 point)**

$\bar{v} = \frac{v+v_o}{2} = \frac{-13.4+0}{2} \rightarrow \bar{v} = -6.7\ m/s$ **(1 point)**

P7. Two blocks with masses $m_A = 12$ kg and $m_B = 3.0$ kg are connected through a frictionless and massless pulley by a lightweight cord. A constant force $\overrightarrow{F}$ is applied on m_A accelerating the blocks as shown. The tension in the cord is 30.0 N.

a. Find the acceleration (a) of the system. **(1 point)**

b. Find the coefficient of kinetic friction (μ_k) between block A and the horizontal surface. **(4 points)**



a. m_B: $y-$ axis: $F_T - m_B g = m_B a \rightarrow a = \frac{F_T - m_B g}{m_B} = 0.2\ m/s^2$ **(1 point)**

b. m_A: $y-$ axis: $F_N + Fsin(30) - m_A g = 0$

$\rightarrow F_N = m_A g - Fsin(30) \rightarrow F_N = 92.6\ N$ **(1 point)**

m_A: $x-$ axis: $Fcos(30) - F_T - F_{fr}^k = m_A a \rightarrow$ **(1 point)**

$\rightarrow Fcos(30) - F_T - \mu_k F_N = m_A a \rightarrow \mu_k = \frac{Fcos(30) - F_T - m_A a}{F_N}$ **(1 point)**

$\rightarrow \mu_k = 0.12$ **(1 point)**