Kuwait University **Physics Department**

Physics 121

Final Exam
Summer Semester (2024-2025)

August 3, 2025
Time: 18:00 – 20:00

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

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

Instructors: Drs. Alfailakawi, Alotaibi, Hadipour, Razee

Important Instructions to the Students:

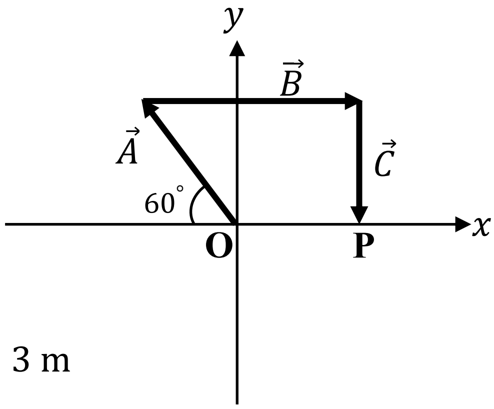
1. Answer all questions and problems.
2. Full mark = 40 points
3. No solution = no points.
4. Take g = 9.8 m/s^2.
5. Mobiles are **strictly prohibited** during the exam.
6. Programmable calculators, which can store equations, are not allowed.
7. **Cheating incidents will be processed according to the university rules.**

For use by Instructors only

#	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	Total
Pts	4	4	4	4	4	3	4	4	5	4	40

GOOD LUCK

P1. An ant travels from point **O** to point **P** by following paths $A = 2$ m and B and C as shown in figure in total time of 4 minutes. The magnitude of the displacement of the ant is $D = 2$ m. Find the average speed of the ant's whole trip from point O to point P. **(4 points)**



$$D_y = 0$$

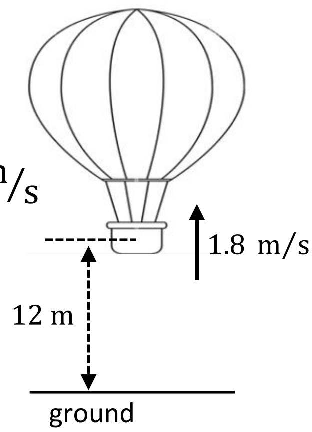
$$D = \sqrt{D_x^2 + D_y^2} \rightarrow 2 = \sqrt{D_x^2} \rightarrow D_x = 2 \text{ m}$$

$$D_x = A_x + B_x = -A cos60^{\circ} + B \rightarrow B = D_x + A cos60^{\circ} = 3 \text{ m}$$

$$C = A sin60^{\circ} = 2 \times 0.86 = 1.73 \text{ m}$$

$$Speed = \frac{A + B + C}{t} = \frac{2 + 3 + 1.73}{4 \times 60} = 0.028 \cong 0.03 \ \frac{\text{m}}{\text{s}}$$

P2. An air balloon moving upward with a constant acceleration of $a = -\,0.3\ \text{m}/s^2$. When the balloon is at 12 m above the ground and has a velocity of 1.8 m/s, a box is released from the balloon. Find the height of the balloon when the box reaches the ground. **(4 points)**



Time for box to reach the ground:

$$v^2 = v_0^2 + 2g(y - y_0) \rightarrow v^2 = 1.8 + 2(-9.8)(0 - 12) \rightarrow v = -15.4 \ {}^{\text{m}}/_{\text{s}}$$

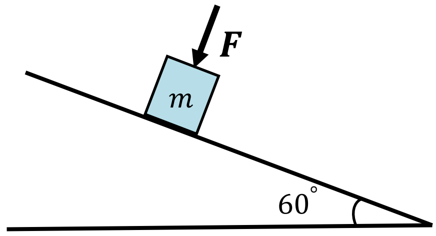
$$v = v_0 + gt \rightarrow -15.4 = 1.8 + (-.9.8)t \rightarrow t = 1.75 \text{ s}$$

Height of the balloon for $t = 1.75$ s:

$$h = y_0 + v_0 t + \frac{1}{2}at^2 \rightarrow h = 12 + (1.8)(1.75) + \frac{1}{2}(-0.3)(1.75)^2$$

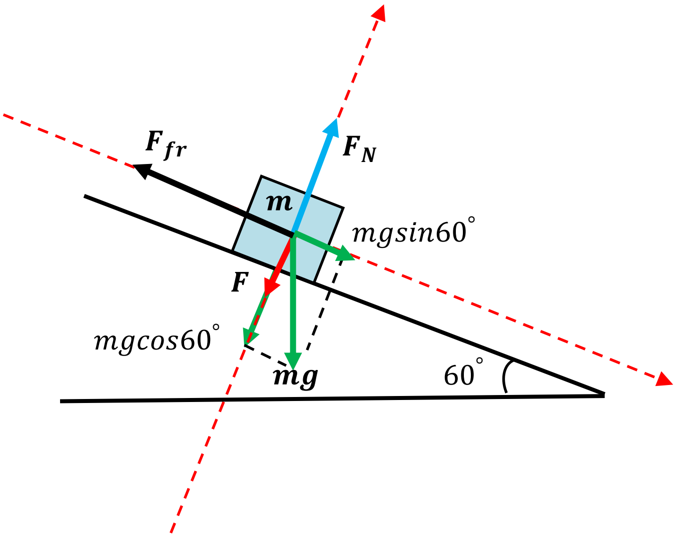
$$h = 14.7 \text{ m}$$

P3. A box of mass $m = 5$ kg is sliding downward on rough surface of an incline while a force perpendicular to the surface of incline with magnitude $F = 34$ N is applied on it as shown. The kinetic coefficient of friction is $\mu_k = 0.2$. Calculate the acceleration of the box? **(4 points)**



$$F_N = F + mgcos60°$$

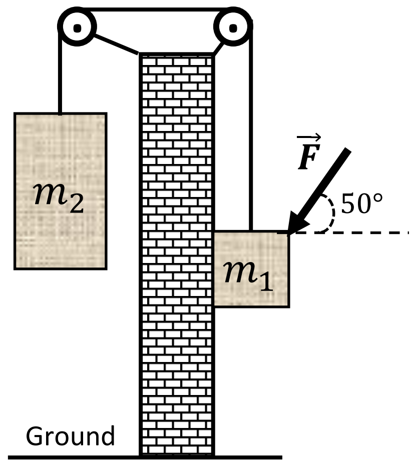
$$F_{fr} = \mu_k \times F_N = \mu_k \times (F + mgcos60^{\circ}) \rightarrow F_{fr} = 11.7 \text{ N}$$



$$mgsin60^{\circ} - F_{fr} = ma \rightarrow a = \frac{mgsin60^{\circ} - F_{fr}}{m}$$

$$a = \frac{(5)(9.8)(0.86) - 11.7}{5} = 6.1 \text{ m/s}^2$$

P4: Two boxes $m_1 = 10$ kg and $m_2 = 28$ kg are connected with a massless cord and two frictionless pullies as shown in figure. The kinetic coefficient of friction between the wall and box 1 is $\mu_k = 0.2$. Find the magnitude of the applied force $\vec{F}$ to allow box 2 to move downward with a constant velocity. **(4 points)**



Box 2:

$$T - m_2 g = 0 \rightarrow T = m_2 g$$

Box 1:

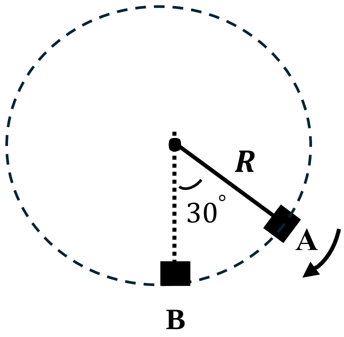
$$F_{fr} = \mu\, F_N = \mu\, Fcos50°$$

$$T - Fsin50° - m_1 g - F_{fr} = 0 \rightarrow (m_2 - m_1)g - F(sin50° + \mu\, cos50°) = 0$$

$$F = \frac{(m_2 - m_1)g}{sin50° + \mu\, cos50°} = 198.6 \text{ N}$$

P5. A box of mass 250 g is connected to a fixed point by a cord of length $R = 15$ cm. It is made to move at a constant speed of $v = 3\ \mathrm{m/s}$ on a vertical circle, as shown.

a) Find the tension force on the cord at point A. **(2 points)**
b) What is the tension force on the cord at point B. **(2 points)**



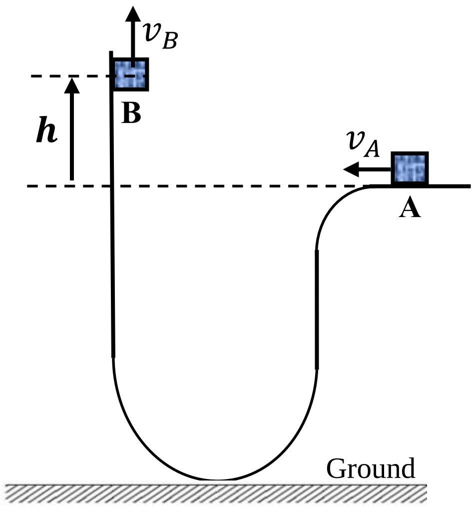
$$\sum F_R = \frac{mv^2}{R} \rightarrow T - mgcos30° = \frac{mv^2}{R}$$

$$T = m\left(\frac{v^2}{R} + gcos30°\right) = 17.1\ \mathrm{N}$$

$$T - mg = \frac{mv^2}{R}$$

$$T = m\left(\frac{v^2}{R} + g\right) = 17.45\ \mathrm{N}$$

P6. A frictionless track is in a vertical plane as shown. A box of mass $m = 1.2$ kg leaves point **A** with speed $v_A = 25\ \mathrm{m/s}$ and arrives at point **B** with speed $v_B = 12\ \mathrm{m/s}$. Find the height difference (h) between points **A** and **B**. **(3 points)**



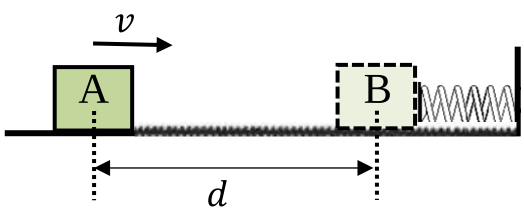
$$W_{mg} = KE_B - KE_A$$

$$W_{mg} = \frac{1}{2}m(v_B^2 - v_A^2) = -288.6\ J$$

$$W_{mg} = -mgh \rightarrow h = \frac{W_{mg}}{-mg} \rightarrow$$

$$h = 24.5\ m$$

P7. A block of mass $m = 1.5$ kg is projected on a rough horizontal ground with coefficient of kinetic friction $\mu_k = 0.2$ from point A with a speed of $12\ \mathrm{m/s}$ and strikes a relaxed spring with stiffness constant of $k = 450\ \mathrm{N/m}$. The block compresses the spring by $x = 0.1$ m and come to the rest at point B as shown. Find the distance between points A and B. **(4 points)**



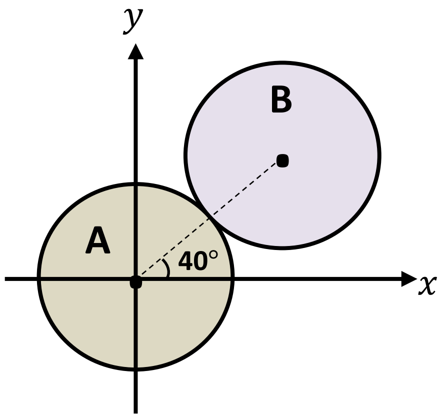
$$W_{fr} = \Delta E = E_B - E_A$$

$$W_{fr} = \frac{1}{2}kx^2 - \frac{1}{2}mv^2 = -105.75\ \mathrm{J}$$

$$F_{fr} = \mu_k \times F_N = \mu_k \times mg = 2.94\ \mathrm{N}$$

$$W_{fr} = -F_{fr} \times d \rightarrow d = \frac{-W_{fr}}{F_{fr}} = \frac{105.75}{2.94} = 36\ \mathrm{m}$$

P8. Two identical disks **A** and **B** with radius $\boldsymbol{r} = 10\ cm$ and mass $\boldsymbol{m}$ are shown. Find the center of mass coordinates X_{CM} and Y_{CM} of the system. **(4 points)**



Disk	x	y
A		
B		

$$x_A = 0\ ;\ y_A = 0$$

$$x_B = 2rcos40°\ ;\ y_B = 2rsin40°$$

$$X_{CM} = \frac{2mrcos40°}{2m} = rcos40° = 7.6\ \mathrm{cm}$$

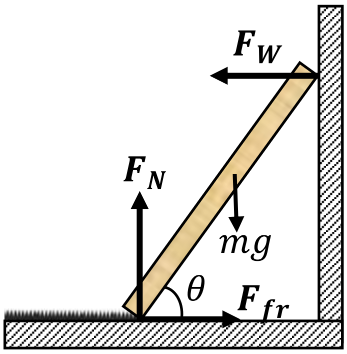
$$Y_{CM} = \frac{2mrsin40°}{2m} = rsin40° = 6.4\ \mathrm{cm}$$

P9. A uniform beam of mass $m = 100$ kg and length L leans against a smooth frictionless wall at angle θ to the ground as shown. The friction force between beam and ground with static coefficient of friction $\mu_s = 0.3$ prevents the beam from slipping.

a) Find the normal force F_N. **(1 point)**

b) Find the friction force F_{fr} **(1 point)**

c) What is the minimum value of angle θ for which the beam will remain static? **(3 points)**



$$\sum F_y = 0 \rightarrow F_N = mg \rightarrow F_N = 980 \text{ N}$$

$$F_{fr} = F_N \times \mu_s = 980 \times 0.3 = 294 \text{ N}$$

$$\sum F_x = 0 \rightarrow F_{fr} = F_W = 294 \text{ N}$$

$$\sum \tau = 0 \rightarrow \tau_{mg} = \tau_{F_W} \rightarrow \frac{L}{2} \times cos\theta \times mg = L \times sin\theta \times F_W \rightarrow \tan\theta = \frac{mg}{2F_W}$$

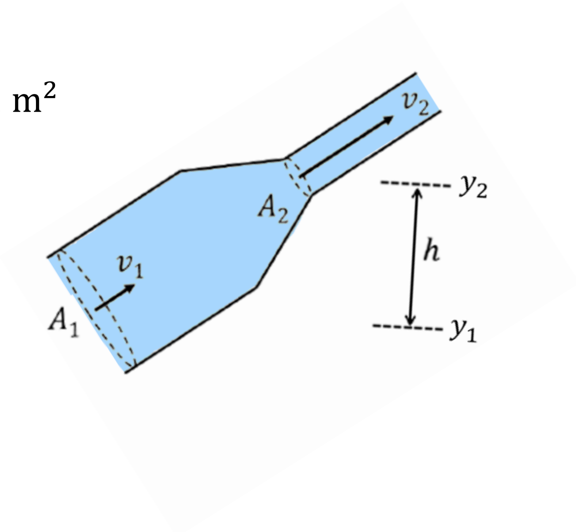
$$\theta = tan^{-1}\left(\frac{mg}{2F_W}\right) \rightarrow \theta = 59°$$

P10. Water ($\rho = 1000 \text{ kg/m}^3$) flows in a pipeline with two different cross section areas as shown. The water speed at the wider section with area $A_1 = 0.5 \text{ m}^2$ is $v_1 = 1.5 \text{ m/s}$ and at the narrow section $v_2 = 7.5 \text{ m/s}$. The pressure difference between narrow and wide sections in the pipeline is $P_1 - P_2 = 36800$ Pa.

a) What is the area of the narrow section of the pipeline? **(1 point)**

b) Find the height difference $h = y_2 - y_1$ between wide and narrow sections. **(3 points)**

$$A_1 v_1 = A_2 v_2 \rightarrow A_2 = \frac{v_1}{v_2} A_1 = \frac{1.5}{7.5}(0.5) \rightarrow A_2 = 0.1 \text{ m}^2$$



$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$$

$$y_2 - y_1 = \frac{\rho(v_1^2 - v_2^2) + 2(P_1 - P_2)}{2\rho g}$$

$$h = y_2 - y_1 = 1 \text{ m}$$