Kuwait University Physics Department

جامعة الكويت
KUWAIT UNIVERSITY

Physics 121

Midterm II Exam
Summer Semester (2024-2025)

July 21, 2025
Time: 18:30 – 20:00

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

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

Instructors: Drs. Alfailakawi, Alotaibi, Hadipour, Razee

Important Instructions to the Students:

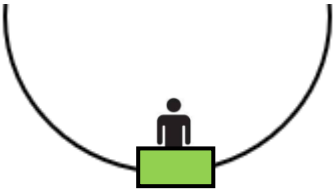
1. Answer all questions and problems.
2. Full mark = 30 points as arranged in the table below.
3. No solution = no points.
4. Take g = 9.8 m/s^2.
5. Mobiles are **strictly prohibited** during the exam.
6. Programmable calculators, which can store equations, are not allowed.
7. **Cheating incidents will be processed according to the university rules.**

For use by Instructors only

#	P1	P2	P3	P4	P5	P6	P7	Total
Pts	4	4	5	4	5	4	4	30

GOOD LUCK

P1. Find the frequency that a Ferries wheel with diameter 50 m must have to make for the passenger to feel three times his regular weight at the bottom most point. **(4 points)**



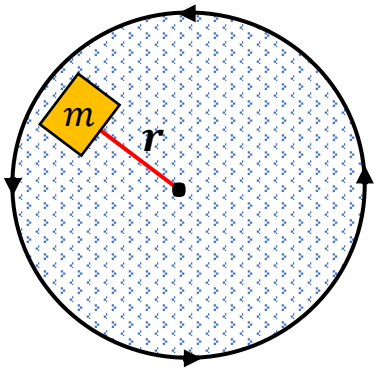
$$F_N = 3\,mg$$

$$\sum F_R = F_N - mg = \frac{mv^2}{R} \rightarrow 2mg = \frac{mv^2}{R}$$

$$v = \sqrt{2Rg} = \sqrt{(2 \times 25 \times 9.8)} = 22.1\ {}^{\mathrm{m}}/_{\mathrm{s}}$$

$$f = \frac{1}{T} = \frac{v}{2\pi R} = \frac{22.1}{2\pi \times 25} = 0.14\ {}^{1}/_{\mathrm{s}}$$

P2. A box of mass $m = 0.3\ kg$ is fixed with a cord to the center of a horizontal rotating table which is moving with speed 180 rpm as shown in figure. The length of the cord is $r = 35\ cm$. Find the coefficient of static friction μ_s between the box and the table if the tension force on the cord is $T = 36.5$ N. **(4 points)**



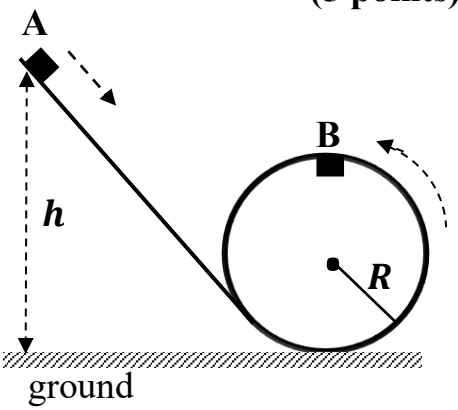
$$f = \frac{180}{60} = 3\ \mathrm{Hz}$$

$$v = 2\pi r f \rightarrow v = 6.6\ {}^{\mathrm{m}}/_{\mathrm{s}}$$

$$T + \mu_s mg = \frac{mv^2}{r} \rightarrow \mu_s = \frac{1}{mg}\left(\frac{mv^2}{r} - T\right)$$

$$\mu_s = 0.28 \cong 0.3$$

P3. A block at rest with mass $m = 0.1$ kg begins to move from point **A** with height $h = 4.5$ m toward point **B** on a frictionless track consisting of an incline and a vertical circular loop of radius $R = 0.8$ m. Find the magnitude of the normal force F_N acting on the block by the track at the top of the loop (at point **B**). **(5 points)**



$$E_A = mgh$$

$$E_B = \frac{1}{2}mv^2 + 2mgR$$

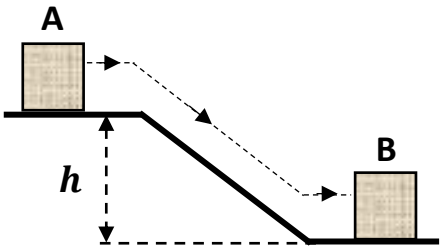
$$E_A = E_B \rightarrow mgh = \frac{1}{2}mv^2 + 2mgR$$

$$v^2 = g(2h - 4R) \rightarrow v = 7.5\ \frac{\text{m}}{\text{s}}$$

$$\sum F_R = \frac{mv^2}{R} = F_N + mg \rightarrow F_N = m\left(\frac{v^2}{R} - g\right) = 6\ \text{N}$$

P4. A box with mass $m = 450$ g is sliding on a frictionless track from point **A** to point **B** in $t = 8$ s while its speed is increased from $v_A = 1\ \text{m/s}$ to $v_B = 4\ \text{m/s}$ as shown in figure.

a) What is the height difference between points A and B? **(2 points)**
b) Calculate the work done by the gravity. **(1 point)**
c) What is the power of the force of gravity? **(1 point)**



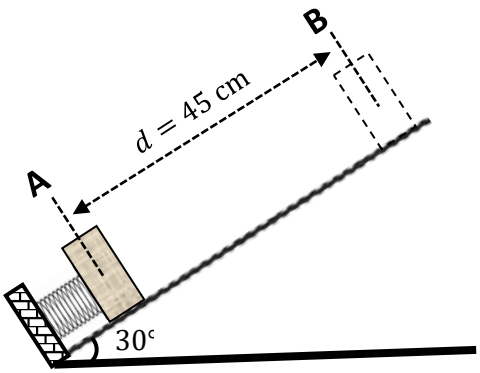
$$E_A = E_B$$

$$\frac{1}{2}mv_A^2 + mgh = \frac{1}{2}mv_B^2 \rightarrow h = 0.76\ \text{m}$$

$$W_G = mgh = 3.35\ \text{J}$$

$$P_{W_G} = \frac{W_{mg}}{t} = \frac{3.35}{8} = 0.4\ \text{W}$$

P5. A spring with stiffness constant of $k = 650$ N/m is mounted on a rough incline while compressed by $x = 18$ cm as shown in figure. A box with mass $m = 3$ kg at the front of the spring is released from rest at point A. The box come to rest again at point B after sliding up for d $= 45\ cm$. Find the coefficient of kinetic friction between the box and the incline surface. **(5 points)**



$$E_A + W_{fr} = E_B$$

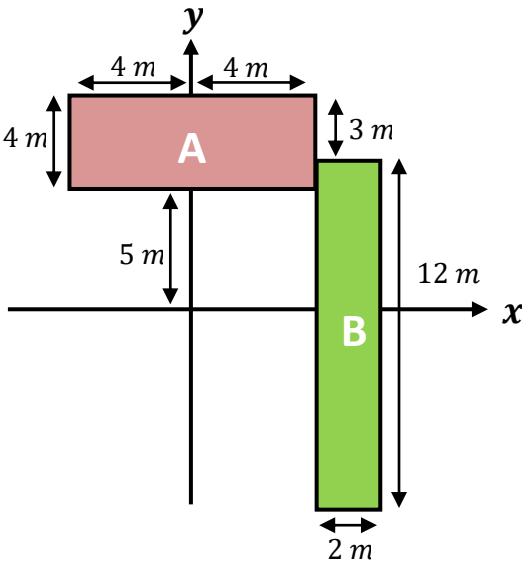
$$h = d \times sin30° = 0.225 \text{ m}$$

$$\frac{1}{2}kx^2 + W_{fr} = mgh \rightarrow W_{fr} = mg(dsin30°) - \frac{1}{2}kx^2 = -3.9 \text{ J}$$

$$W_{fr} = -F_{fr} \times d \rightarrow F_{fr} = \frac{-W_{fr}}{d} = 8.66 \text{ N}$$

$$F_{fr} = \mu_k \times F_N \rightarrow \mu_k = \frac{F_{fr}}{F_N} = \frac{F_{fr}}{mgcos30°} = 0.34$$

P6. Two rectangular blocks with identical mass $m_A = m_B = m$ are shown. Find the position of the center of mass (CM) of the system. **(4 points)**



$$X_{CM} = \frac{m_A x_A + m_B x_B}{m_A + m_B} = \frac{m \times (0 + 5)}{2m}$$

$$X_{CM} = 2.5 \text{ m}$$

$$Y_{CM} = \frac{m_A y_A + m_B y_B}{m_A + m_B} = \frac{m \times (7 + 0)}{2m}$$

$$Y_{CM} = 3.5 \text{ m}$$

P7. A car's wheel with diameter 76 cm makes 90 revolutions while its speed uniformly increases from rest to 60 km/h. Calculate the angular acceleration of the wheel. **(4 points)**

$$v = \frac{60}{3.6} = 16.6\ \frac{m}{s}$$

$$\omega = \frac{v}{r} = \frac{16.6}{0.38} = 43.7\ {}^{\text{rad}}/_{\text{s}}$$

$$\Delta\theta = N \times 2\pi = 90 \times 2\pi = 565.2\ \text{rad}$$

$$\omega^2 = \omega_0^2 + 2\alpha\Delta\theta \rightarrow \alpha = \frac{\omega^2 - \omega_0^2}{2\Delta\theta} = \frac{(43.7)^2 - 0}{2 \times 565.2} = 1.7\ {}^{\text{rad}}/_{\text{s}^2}$$