**Kuwait University** **Physics Department**

جامعة الكويت
KUWAIT UNIVERSITY

# Physics 121

## Midterm II Exam
## Spring Semester (2024-2025)

**April 15, 2025**
**Time: 18:30 – 20:00**



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

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

**Instructors: Drs.** Abdulmohsen, Alfailakawi, Alotaibi, Burahmah, Hadipour, Kokkalis, Razee

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## Important Instructions to the Students:

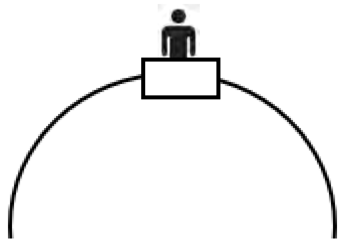
1. Answer all questions and problems.
2. Full mark = 30 points as arranged in the table below.
3. No solution = no points.
4. **Use SI units.**
5. Take $g = 9.8\ m/s^2$.
6. Mobiles are **strictly prohibited** during the exam.
7. Programmable calculators, which can store equations, are not allowed.
8. **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 | 5 | 5 | 4 | 4 | 4 | 30 |
| | | | | | | | | |

GOOD LUCK

**P1.** A Ferries wheel with diameter 32 m rotates with constant frequency $f$. A passenger at the topmost point has an apparent weight half of his actual weight. Find the rotation frequency of the Ferries wheel. **(4 points)**



$$F_N = \frac{1}{2}mg$$

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

$$\rightarrow \frac{1}{2}mg = \frac{mv^2}{R}$$

$$v = \sqrt{\frac{Rg}{2}} = \sqrt{\frac{16 \times 9.8}{2}} = 8.85\ {}^{\mathrm{m}}/_{\mathrm{s}}$$

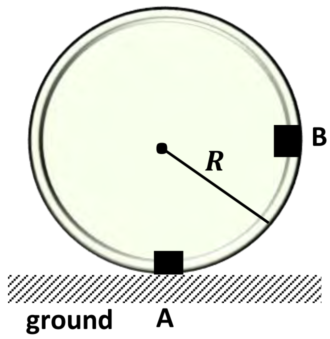
$$f = \frac{1}{T} = \frac{v}{2\pi R} = \frac{8.85}{2\pi \times 16} = 0.09\ {}^{1}/_{\mathrm{s}}$$



**P2.** A circular loop of radius $R = 0.4$ m is fixed to the ground. A box of mass $\mathrm{m} = 1.5$ kg is sliding along the inside surface of the loop, as shown. The normal force acting on the box at point A is $F_N = 80$ N. Find the velocity of the box at point B. Ignore friction.

a) Find the velocity of the box at point A. **(2 points)**

b) What is the velocity of the box at point B? **(2 points)**

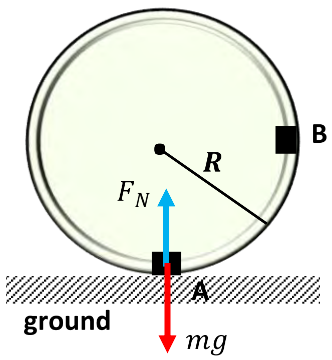



$$\sum F_R = \frac{mv^2}{R} \rightarrow F_N - mg = \frac{mv_A^2}{R}$$

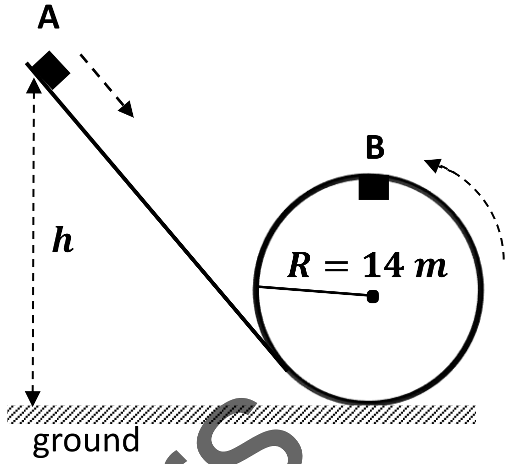
$$v_A^2 = \frac{R(F_N - mg)}{m} \rightarrow v_A = 4.2\ {}^{\mathrm{m}}/_{\mathrm{s}}$$

$$\frac{1}{2}mv_A^2 = \frac{1}{2}mv_B^2 + mgR \rightarrow v_B^2 = v_A^2 - 2gR$$

$$v_B = \sqrt{(4.2)^2 - 2(9.8)(0.4)} = 3.1\ {}^{\mathrm{m}}/_{\mathrm{s}}$$



**P3.** A rollercoaster cabin with mass $m$ begins to move from rest at point A toward point B through a frictionless track as shown. Find the minimum height ($h$) so that the cabin follows the track without falling at point B ($F_N = 0$ N). **(5 points)**




$$E_A = mgh$$

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

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

$$\sum F_R = \frac{mv^2}{R} = mg \rightarrow v^2 = gR$$

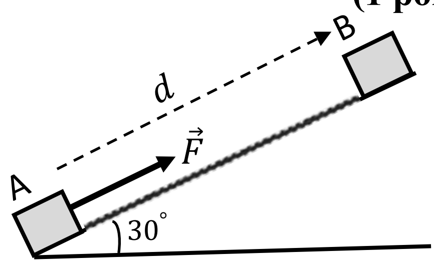
$$gh = \frac{1}{2}gR + 2gR \rightarrow h = \frac{5}{2}R \rightarrow h = 35 \text{ m}$$



**P4.** A box of mass $m = 1000$ kg is pulled upward by force $\vec{F}$ along an inclined rough surface as shown. The box uniformly accelerates from rest (point A) to a speed of $18$ m/s in $8$ seconds, and over distance of $d = 72$ m (point B). The average force of friction is $F_{fr} = 1600$ N.

a) Find the magnitude of the applied force $\vec{F}$. **(4 points)**

b) What is the average power of the force $\vec{F}$? **(1 point)**

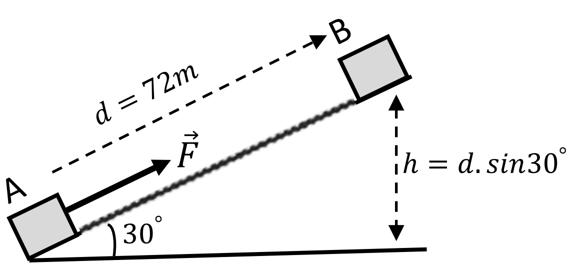



$$W_{NC} = \Delta KE + \Delta PE$$

$$W_F + W_{fr} = \Delta KE + \Delta PE \rightarrow W_F - F_{fr}d = \frac{1}{2}mv^2 + mgh$$

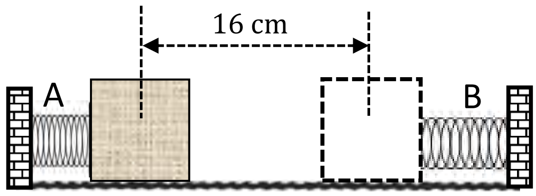
$$W_F = \frac{1}{2}mv^2 + mg(d.\sin 30^\circ) + F_{fr}d = 630 \text{ kJ}$$

$$W_F = F.d \rightarrow F = \frac{W_F}{d} = 8750 \text{ N}$$




$$\bar{P}_F = \frac{W_F}{t} = \frac{630}{8} = 78.75 \text{ kW}$$

**P5.** Two identical springs, A and B, each with stiffness constant $k = 650\ \mathrm{N/m}$, are mounted horizontally as shown in figure. A box with mass $m = 11$ kg at the front of the spring A, while compressed for $x_A = 15$ cm, is released from rest. The box, after sliding on rough ground for $\mathrm{d} = 16$ cm, hits the spring B compressing it for $x_B = 7$ cm until momentary stops. Find the kinetic coefficient of friction between the box and the ground. **(4 points)**




$$W_{NC} = \Delta KE + \Delta PE$$

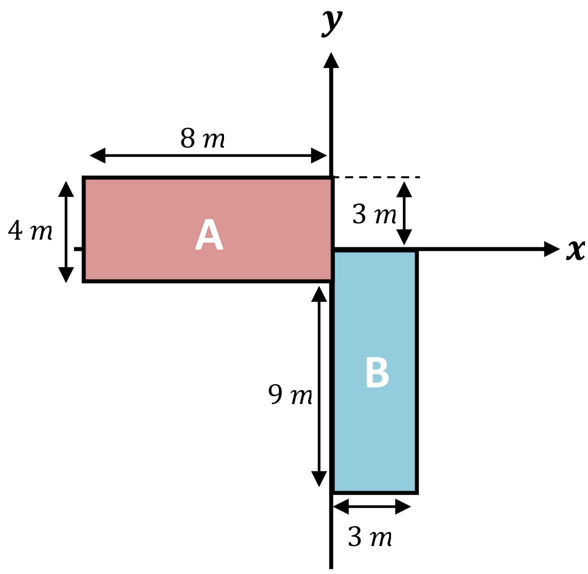
$$W_{fr} = \frac{1}{2}k(x_B^2 - x_A^2) = -5.72\ \mathrm{J}$$

$$W_{fr} = -F_{fr} \times d \rightarrow F_{fr} = \frac{5.72}{0.16 + 0.07} = 24.87\ \mathrm{N}$$

$$F_{fr} = \mu\, F_N = \mu\, mg \rightarrow \mu = \frac{F_{fr}}{mg} = 0.23$$



**P6.** Two rectangular blocks of mass $m_A = 5$ kg, $m_B = 2$ kg are shown. Find the position of the center of mass (CM) of the system. **(4 points)**




$$X_{CM} = \frac{m_A x_A + m_B x_B}{m_A + m_B} = \frac{(5) \times (-4) + (2) \times (1.5)}{5 + 2}$$

$$X_{CM} = -2.4\ \mathrm{m}$$

$$Y_{CM} = \frac{m_A y_A + m_B y_B}{m_A + m_B} = \frac{(5) \times (1) + (2) \times (-5)}{5 + 2}$$

$$Y_{CM} = -0.71\ \mathrm{m}$$

**P7.** A car's wheel with radius 42 cm makes 70 revolutions while slows down uniformly from 13.9 m/s to complete stop. Calculate the angular acceleration of the wheel. **(4 points)**

$$\omega_0 = \frac{v_0}{r} = \frac{13.9}{0.42} = 33.1\ \mathrm{rad}/\mathrm{s}$$

$$\Delta\theta = N \times 2\pi = 70 \times 2\pi = 439.6\ \mathrm{rad}$$

$$\omega^2 = \omega_0^2 + 2\alpha\Delta\theta \rightarrow \alpha = \frac{\omega^2 - \omega_0^2}{2\Delta\theta} = \frac{0 - (33.1)^2}{2 \times 439.6} = -1.25\ \mathrm{rad}/\mathrm{s}^2$$