Kuwait University Physics Department

Physics 121

Second Midterm Exam
Summer Semester (2025-2026)

July 11, 2026
Time: 13:00 – 14:30

Student's Name: ……………………………………………. Serial Number: ……………

Student's Number: …………………………………………….. Section: ……………………

Instructors: Drs. Alrefai, Alotaibi, Burahmah, Hadipour, Kokkalis

Important:

1. Answer all questions and problems (No solution = no points).
2. Full mark = 28 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 <u>**strictly prohibited**</u> during the exam.
6. Programmable calculators, which can store equations, are not allowed.
7. **Cheating incidents will be processed according to the university rules.**

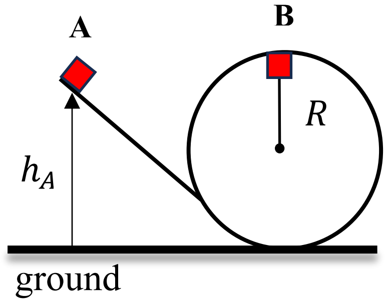
For use by instructors

Grades:

#	P1	P2	P3	P4	P5	P6	P7	Total
Pts	**3**	**5**	**3**	**4**	**4**	**5**	**4**	**28**

GOOD LUCK

P1. A small box starts at point **A** with an initial speed of $v_A = 5\ \mathrm{m/s}$ and moves along a frictionless track consisting of an inclined section followed by a circular section of radius $R = 1.2$ m, as shown in the figure. The box reaches the highest point (**B**) of the circular path with speed $v_B = 4\ \mathrm{m/s}$. **Determine the height (h_A) of point A above the ground.** **(3 points)**

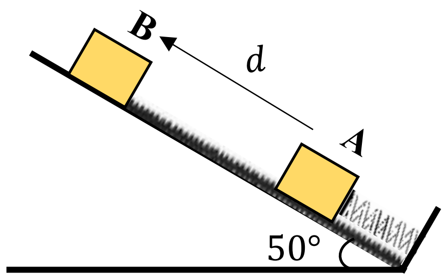


$$E_A = E_B \rightarrow \frac{1}{2}mv_A^2 + mgh_A = \frac{1}{2}mv_B^2 + mgh_B$$

$$mgh_A + \frac{1}{2}mv_A^2 = \frac{1}{2}mv_B^2 + mg2R$$

$$h_A = 2R + \frac{v_B^2}{2g} - \frac{v_A^2}{2g} = 1.94\ \mathrm{m}$$

P2. A block of mass $m = 5$ kg is held against a compressed spring at point **A**. The spring has a stiffness constant of $k = 850\ \mathrm{N/m}$ and is compressed by $x = 40$ cm. When released, the block moves up a rough inclined surface and travels over a distance $d = 1.5$ m before coming to rest at point **B**. **Find the coefficient of kinetic friction μ_k between the block and the inclined surface.** **(5 points)**



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

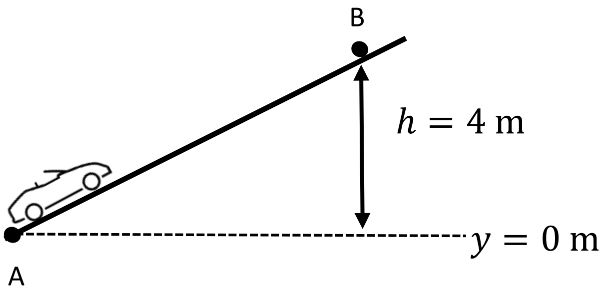
$$W_{fr} = -F_{fr}.d = -\mu_k F_N.d = -\mu_k mgcos50°.d$$

$$h = d.sin50° = 1.15\ m$$

$$-\mu_k mgcos50°.d = (0 - mgh) + \left(0 - \frac{1}{2}kx^2\right)$$

$$\mu_k = \frac{kx^2 - 2mgh}{2mgcos50°.d} = 0.25$$

P3. A 1100 kg car starts (point A) with a speed of 9 $\mathrm{m/s}$ at the bottom of a 4 m-high incline and reaches the top (point B) with a speed of 20 $\mathrm{m/s}$ in 11 s. Assume that is there is no friction during the motion. What was the average power delivered by the engine during this motion? **(3 points)**



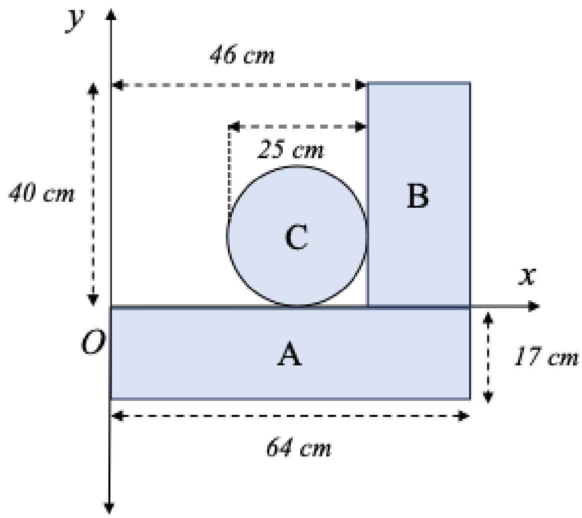
$$W_{NC} = \Delta KE + \Delta PE$$

$$W_{engine} = \left(\frac{1}{2}\mathrm{m}v_B^2 + mgh_B\right) - \left(\frac{1}{2}\mathrm{m}v_A^2 + 0\right)$$

$$W_{engine} = 2.19 \times 10^5 J$$

$$\bar{P}_{engine} = \frac{W_{engine}}{t} = 1.99 \times 10^4\ W$$

P4. Three plates of different shape are placed as shown. The masses of plates $A, B,$ and C, are 0.20 kg, 0.15 kg, and 1.0 kg. **Find the x−coordinate and the y−coordinate of the center of mass of the system.** **(4 points)**



$$X_{CM} = \frac{x_A m_A + x_B m_B + x_C m_C}{m_A + m_B + m_C}$$

$$= \frac{32 \times 0.20 + 55 \times 0.15 + 33.5 \times 1.0}{0.20 + 0.15 + 1.0}$$

$$X_{CM} = 35.7\ cm$$

$$Y_{CM} = \frac{y_A m_A + y_B m_B + y_C m_C}{m_A + m_B + m_C}$$

$$= \frac{-8.5 \times 0.20 + 20 \times 0.15 + 12.5 \times 1.0}{0.20 + 0.15 + 1.0}$$

$$Y_{CM} = 10.2\ cm$$

P5. The leg of an athlete during a stretching position is bent at 90^o, as shown below. The upper leg (ul), lower leg (ll), and feet (f) have masses $m_{ul} = 15.1$ kg, $m_{ll} = 6.72$ kg, and $m_f = 2.38$ kg, respectively. The positions of their centers-of-mass are indicated by the symbol " **x** ". **Find the *x* and *y*–coordinates of the center-of-mass of the entire leg, measured from the origin (point O).** **(4 points)**

$$X_{CM} = \frac{x_{ul}m_{ul} + x_{ll}m_{ll} + x_f m_f}{m_{ul} + m_{ll} + m_f}$$

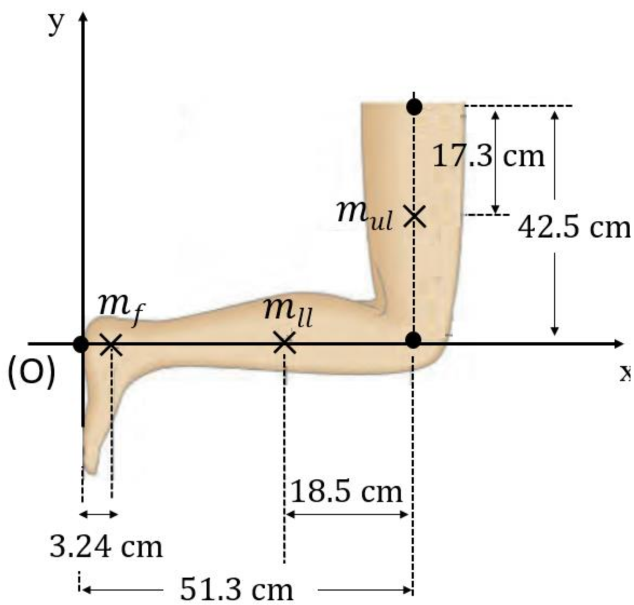
$$= \frac{51.3 \times 15.1 + (51.3 - 18.5) \times 6.72 + 3.24 \times 2.38}{15.1 + 6.72 + 2.38}$$

$$X_{CM} = 41.4\ cm$$

$$Y_{CM} = \frac{y_{ul}m_{ul} + y_{ll}m_{ll} + y_f m_f}{m_{ul} + m_{ll} + m_f}$$

$$= \frac{(42.5 - 17.3) \times 15.1 + 0 \times 6.72 + 0 \times 2.38}{15.1 + 6.72 + 2.38}$$

$$Y_{CM} = 15.7\ cm$$



P6. A rotating wheel **accelerates uniformly** from 10 rpm to 40 rpm in 4 s.

a. Find its angular acceleration. **(2 points)**

b. Find the magnitude of the total acceleration of a point located 15 cm from the center when the wheel is rotating at 10 rpm. **(3 points)**

(a) $\omega_o = 2\pi f_o = 2\pi \frac{10}{60}\ rad/s$; $\omega = 2\pi f = 2\pi \frac{40}{60}\ rad/s$;

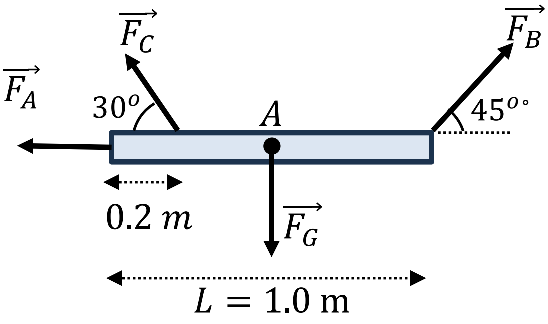
$$\omega = \omega_o + \alpha t \rightarrow \alpha = \frac{\omega - \omega_o}{t} = \frac{2\pi \frac{30}{60}}{4} = 0.8\ rad/s^2$$

(b) $a_{tan} = r\alpha = 0.15 \times 0.8 = 0.12\ m/s^2$

$$a_{rad} = \omega_o^2 r = \left(2\pi \frac{10}{60}\right)^2 0.15 = 0.16\ m/s^2$$

$$a = \sqrt{a_{tan}^2 + a_{rad}^2} = \sqrt{0.16^2 + 0.12^2} = 0.2\ m/s^2$$

P7. A uniform bar of length $L = 1$ m and mass $m = 5$ kg is free to rotate about a fixed axis through its centre (point A). Three forces act on it as shown in the figure, with magnitudes $F_A = 20$ N, $F_B = 30$ N, and $F_C = 40$ N. **Find the net torque about A.** **(4 points)**



$\tau_{F_A} = 0\ N.m$

$\tau_{F_B} = r_B F_B sin\theta_B = (0.5)(30)sin45^\circ = 10.6\ N.m$

$\tau_{F_G} = 0\ N.m$

$\tau_{F_C} = -r_C F_C sin\theta_C = -(0.5 - 0.2)(40)sin30^\circ = -6\ N.m$

$\tau_{net} = \tau_{F_A} + \tau_{F_B} + \tau_{F_G} + \tau_{F_C} = 0 + 10.6 + 0 - 6 = +4.6\ N.m$

The net torque is counter-clockwise