Kuwait University   Department of Physics

جامعة الكويت
KUWAIT UNIVERSITY

General Physics I for Biological Sciences (Phy 121)

Second Midterm Examination

Spring Semester 2023-2024

May 4, 2024
Time: 3:00 PM to 4:30 PM

Instructors: **Dr. Abdullah, Dr. Afrousheh, Dr. Al-Otaibi, Dr. Hadipour, Dr. Kokkalis, Dr. Razee and Dr. Zaman**

Name:... **Student ID:**...........................

Section:....................................... **Serial No.:**..............................

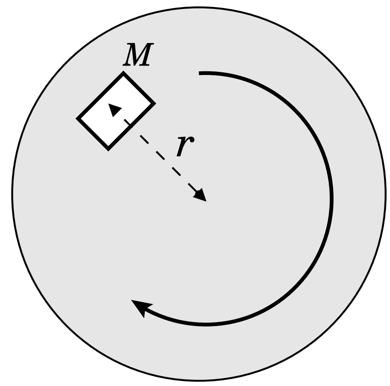
Instructions to the Students:

- Answer all the questions. Show all your working in this booklet.
- All communication devices must be switched off and placed in your bag or deposited with the invigilator in charge. Anyone found using a communication device will be disqualified.
- Programmable calculators, which can store equations, are not allowed. You may use a non-programmable calculator.
- Cheating incidents will be processed according to the University rules.
- **Use SI units.**
- **Take $g = 9.8$ m/s^2.**

For use by instructors only

Problem #	P1	P2	P3	P4	P5	P6	P7	Total
Max. Marks	**4**	**4**	**4**	**4**	**4**	**4**	**5**	**29**
Marks								

1. A box of mass $M = 0.1$ kg rests at a distance of $r = 25$ cm from the centre of a horizontal rotating table. The box remains at its place until the frequency of rotation reaches 45 rpm. Find the coefficient of static friction (μ_s) between the box and the table. **4 points**



Solution: We have

$$f = 45/60 = 0.75 \text{ s}^{-1}$$

$$v = 2\pi r f = 1.18 \text{ m/s}$$

The force equation,

$$\mu_s M g = \frac{Mv^2}{r} \implies \mu_s = \frac{v^2}{rg} = 0.57$$

2. A bicycle tire with radius $r = 50$ cm makes 64 revolutions while its speed uniformly reduces from 36 km/h to complete stop. Find the angular acceleration of the tire. **4 points**

Solution: The initial speed and the initial angular speed are

$$v_0 = 36/3.6 = 10 \text{ m/s}$$

$$\omega_0 = \frac{v_0}{r} = 20 \text{ rad/s}$$

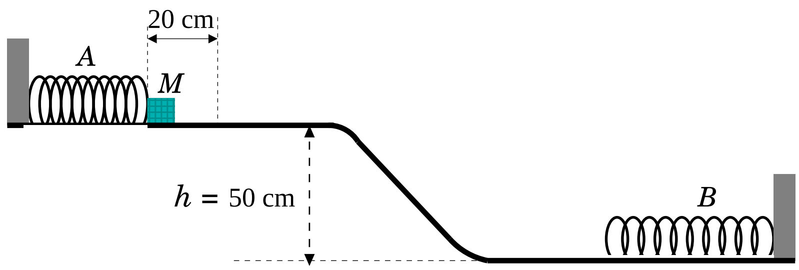
The total angle covered is

$$\theta - \theta_0 = N \times 2\pi = 402 \text{ rad}$$

Then

$$\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0) \implies \alpha = \frac{\omega^2 - \omega_0^2}{2(\theta - \theta_0)} = -0.5 \text{ rad/s}^2$$

3. A 2-kg box is used to compress the spring A with stiffness constant $k_A = 850$ N/m by 20 cm. When the box is released it slides down a frictionless path and hits spring B with stiffness constant $k_B = 600$ N/m. Find the compression in spring B when the box comes momentarily to rest. **4 points**



Solution: The work-energy principle is

$$\text{KE}_i + \text{PE}_i = \text{KE}_f + \text{PE}_f$$

$$\Longrightarrow\ 0 + Mgh + \frac{1}{2}k_A x_A^2 = 0 + 0 + \frac{1}{2}k_B x_B^2$$

$$\Longrightarrow\ 2 \times 9.8 \times 0.5 + \frac{1}{2} \times 850 \times (0.2)^2 = \frac{1}{2} \times 600 \times x_B^2$$

$$\Longrightarrow\ 26.8 = \frac{1}{2} \times 600 \times x_B^2$$

$$\Longrightarrow\ x_B = 0.30 \text{ m}$$

4. A 1000-kg car moving on a horizontal road accelerates uniformly from rest to a speed of 15 m/s in 8 s during which it travels a distance of 60 m. The average power of the car's engine is 20 kW. Find the average force of friction on the car. **4 points**

Solution: We have

$$P_{engine} = \frac{W_{engine}}{t} \Longrightarrow W_{engine} = P_{engine} t = (20 \times 10^3) \times 8 = 1.6 \times 10^5 \text{ J}$$

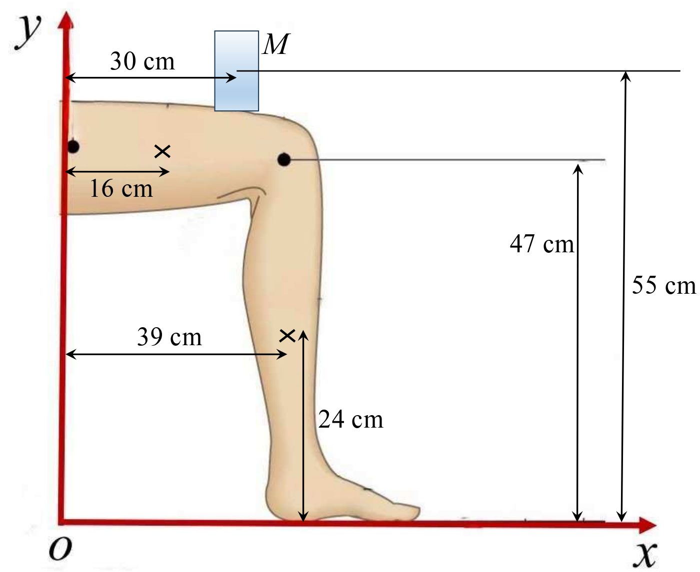
The work-energy principle gives

$$W_{engine} + W_{fr} = \frac{1}{2}Mv^2 \Longrightarrow W_{fr} = \frac{1}{2}Mv^2 - W_{engine} = -4.75 \times 10^4 \text{ J}$$

Work done by the force of friction is

$$W_{fr} = -F_{fr}d \Longrightarrow F_{fr} = \frac{-W_{fr}}{d} = 792 \text{ N}$$

5. A pile of books of mass $M = 8$ kg is placed on a leg bent at 90^o as shown. The masses of the upper leg, the lower leg (with the foot) are respectively $M_1 = 9$ kg and $M_2 = 7$ kg. The lengths of different parts are shown in the figure. Find the centre of mass of the leg holding the books. **4 points**



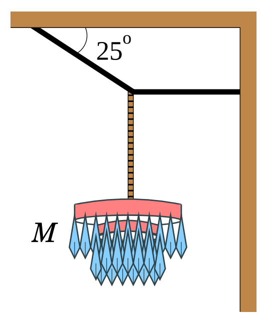
Solution:

$M_1 = 9$ kg	$x_1 = 16$ cm	$y_1 = 47$ cm
$M_2 = 7$ kg	$x_2 = 39$ cm	$y_2 = 24$ cm
$M = 8$ kg	$x = 30$ cm	$y = 55$ cm

$$x_{CM} = \frac{M_1 x_1 + M_2 x_2 + M x}{M_1 + M_2 + M} = 27.4 \text{ cm}$$

$$y_{CM} = \frac{M_1 y_1 + M_2 y_2 + M y}{M_1 + M_2 + M} = 43.0 \text{ cm}$$

6. Two ropes support a hanging chandelier as shown. If the tension in the horizontal rope is 50 N, find the mass of the chandelier. **4 points**

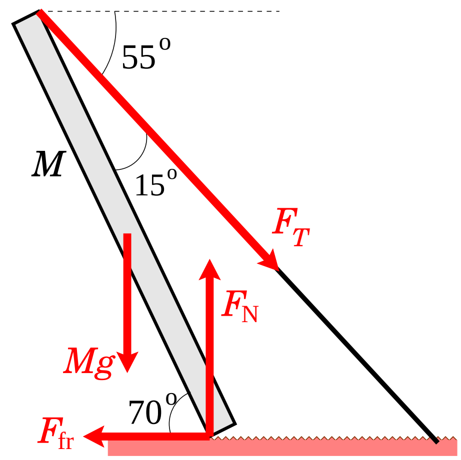


Solution: Let the tensions in the two ropes be F_{T1} (horizontal rope) and F_{T2}. Then

$$F_{T1} - F_{T2}\ \cos 25^o = 0 \implies F_{T2} = \frac{F_{T1}}{\cos 25^o} = 55 \text{ N}$$

$$F_{T2}\ \sin 25^o - Mg = 0 \implies M = \frac{F_{T2}\ \sin 25^o}{g} = 2.4 \text{ kg}$$

7. A 80-kg uniform bar is made to stand tilted at 70^o to the horizontal on a rough horizontal surface by a cord connecting the top of the bar to the ground as shown. The system is in equilibrium. The forces acting on the bar are shown in the figure.



(a) Find the tension in the cord. **2 points**

(b) Find the normal force on the bar by the ground. **2 points**

(c) Find the force of friction on the bar by the rough surface. **1 point**

Solution: Let L be the length of the bar. We choose the pivot at the point where the bar touches the ground. Then the second condition of equilibrium gives us

$$+Mg \times \frac{L}{2} \times \sin 20^o - F_T \times L \times \sin 15^o = 0$$

$$\Longrightarrow F_T = \frac{Mg\ \sin 20^o}{2\ \sin 15^o} = 518 \text{ N}$$

Force ($y-$component): $-F_T\ \sin 55^o - Mg + F_N = 0$

$$\Longrightarrow F_N = F_T\ \sin 55^o + Mg = 1208 \text{ N}$$

Force ($x-$component): $+F_T\ \cos 55^o - F_{fr} = 0 \Longrightarrow F_{fr} = F_T\ \cos 55^o = 297 \text{ N}$