Kuwait University Department of Physics

جامعة الكويت
KUWAIT UNIVERSITY

General Physics I for Biological Sciences (Phy 121)

Second Midterm Examination

Fall Semester 2025-2026

November 27, 2025

Time: 6:30 PM to 8:00 PM

Instructors: **Dr. Al-Failakawi, Dr. Al-Otaibi, Dr. Al-Refai, Dr. Burahmah, Dr. Hadipour, Dr. Kokkalis and Dr. Razee**

Solution

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**.

1. A 1200-kg car traveling on a horizontal road encounters a net frictional force of magnitude $F_{fr} = 500$ N. The car needs to **accelerate from rest to 126 km/h** in 20 s. What average power of the engine is required? **4 points**

Solution: To accelerate from rest to 126 km/h (35 m/s) in 20 s, **net** acceleration needed is

$$a = \frac{35}{20} = 1.75 \text{ m/s}^2$$

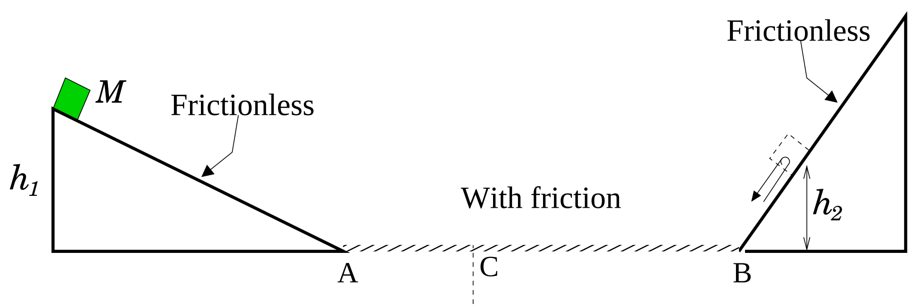
The net force applied by the engine is

$$F_{engine} = Ma + F_{fr} = 2600 \text{ N}$$

The power delivered by the engine is

$$P_{engine} = F_{engine}\overline{v} = 2600 \times \frac{1}{2} \times 35 = 45500 \text{ W}$$

2. A horizontal rough surface of length $AB = 2.5$ m lies between two frictionless inclines as shown. A box is released from rest at a height $h_1 = 80$ cm on the first incline. It slides through the horizontal surface, climbs up to a height h_2 on the second incline, **returns on its path and stops at** C. The length $BC = 1.5$ m. Find h_2. **4 points**



Solution: First, we need to find the coefficient of kinetic friction (μ_k) between the box and the horizontal surface.

The work-energy principle from start to the point C is

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

$$\Longrightarrow\ 0 + Mgh_1 - \mu_k Mg(AB + BC) = 0 + 0$$

$$\Longrightarrow\ \mu_k = \frac{h_1}{AB + BC} = 0.20$$

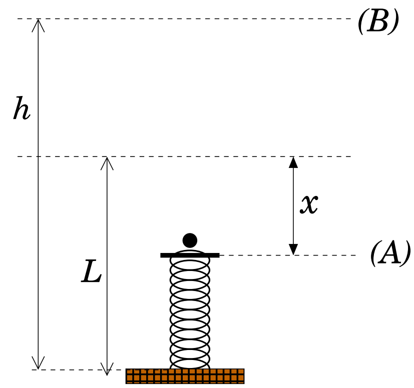
Now, the work-energy principle from start to the height h_2 is

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

$$\Longrightarrow\ 0 + Mgh_1 - \mu_k Mg(AB) = 0 + Mgh_2$$

$$\Longrightarrow\ h_2 = h_1 - \mu_k \times (AB) = 0.30 \text{ m}$$

3. A vertical unstretched spring stands $L = 22$ cm above the ground. A small ball of mass 0.15 kg is used to compress the spring by 5 cm and it was released from there (point A). The ball was moving with speed 2.4 m/s when it was $h = 40$ cm above the ground (point B). Ignore air resistance.



   (a) Find the spring constant. **2 points**

   (b) Find the maximum height reached by the ball. **2 points**

   Solution: We take the gravitational potential energy to be zero at the ground. The work-energy principle from start to the height $h = 40$ cm is

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

$$\Longrightarrow\ 0 + Mg \times 0.17 + \frac{1}{2}k(0.05)^2 = \frac{1}{2}Mv^2 + Mg \times 0.4 + 0$$

$$\Longrightarrow\ k = 616 \text{ N/m}$$

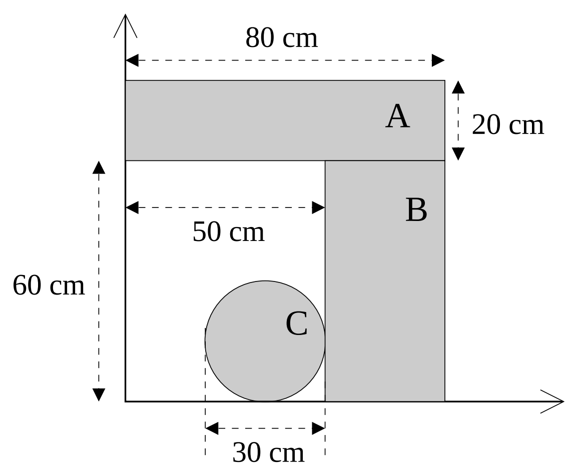
   The work-energy principle from start to the maximum height is

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

$$\Longrightarrow\ 0 + Mg \times 0.17 + \frac{1}{2}k(0.05)^2 = 0 + MgH + 0$$

$$\Longrightarrow\ H = 0.69 \text{ m}$$

4. The figure shows three objects, A, B and C, arranged in the $xy-$plane. The masses are $M_A = 200$ g, $M_B = 150$ g and $M_C = 100$ g. Find the $x-$coordinate and the $y-$coordinate of the centre of mass of the system. **4 points**



   Solution:

$M_A = 200$ g	$x_A = 40$ cm	$y_A = 70$ cm
$M_B = 150$ g	$x_B = 65$ cm	$y_B = 30$ cm
$M_C = 100$ g	$x_C = 35$ cm	$y_C = 15$ cm

$$x_{CM} = \frac{M_A x_A + M_B x_B + M_C x_C}{M_A + M_B + M_C} = 47.2 \text{ cm}$$

$$y_{CM} = \frac{M_A y_A + M_B y_B + M_C y_C}{M_A + M_B + M_C} = 44.4 \text{ cm}$$

5. A rotating wheel slows down uniformly from 2000 rpm to 300 rpm in 15 s after being switched off.

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

   (b) How many rotations the wheel completeted in these 15 s? **2 points**

Solution:

$$\omega_0 = \frac{2000 \times 2\pi}{60} = 209.4 \text{ rad/s} \qquad \omega = \frac{300 \times 2\pi}{60} = 31.4 \text{ rad/s}$$

$$\alpha = \frac{\omega - \omega_0}{15} = -11.9 \text{ rad/s}^2$$

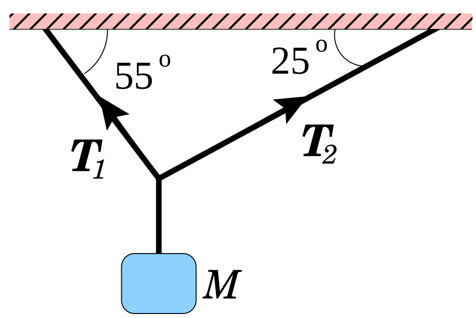
$$\theta - \theta_0 = \overline{\omega} t = \frac{1}{2} \times (\omega_0 + \omega) \times 15 = 1806 \text{ rad}$$

$$N = \frac{\theta - \theta_0}{2\pi} = 287$$

6. A box of mass M hangs from the ceiling with the help of two ropes as shown. The box is in equilibrium. The tension $T_1 = 30$ N.

   (a) Find the tension T_2. **2 points**

   (b) Find the mass M of the box. **2 points**



Solution: The horizontal components of all the forces add up to zero,

$$-T_1 \ \cos 55^o + T_2 \ \cos 25^o = 0 \implies T_2 = 19 \text{ N}$$

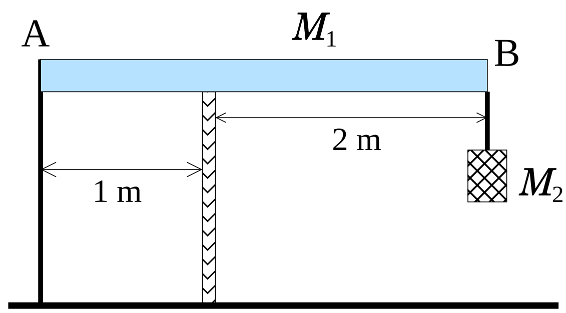
The vertical components of all the forces add up to zero,

$$T_1 \ \sin 55^o + T_2 \ \sin 25^o - Mg = 0 \implies M = 3.3 \text{ kg}$$

7. A horizontal uniform bar AB of mass $M_1 = 50$ kg rests on a vertical pole as shown. The left-end (A) is connected to the ground by a massless vertical cable. A box of mass M_2 hangs from the other end of the bar. The tension in the cable at A is $F_T = 1900$ N. The structure is in equilibrium.

   (a) Find M_2. **2 points**

   (b) Find the force exerted by the vertical pole on the bar. **2 points**



Solution: The free-body diagram is shown. We choose the **pivot at the point of contact of the vertical pole and the bar**. Then the net torque on the bar is,

$$+F_T \times 1 - M_1 g \times 0.5 - M_2 g \times 2 = 0$$

$$\implies M_2 = \frac{F_T - M_1 g \times 0.5}{2g} = 84 \text{ kg}$$

The net force is zero,

$$-F_T + F_N - M_1 g - M_2 g = 0 \implies F_N = 3217 \text{ N}$$