Energy, Work, Electricity MOCK EXAM

1	The mass of a truck is 10000 kg and is rolling up a hill at a constant speed. The power of the truck is 230 HP and the angle of the slope is 8º . If the value of the friction force is 6000 N, find the speed of the truck
1 HP = 736 W	

(1) We can relate the power of the truck, its velocity and the force F

$$P = F \times v$$

$$P = 230\ HP \times \frac{736\ W}{1\ HP} = 169\,280\ W$$

The force needed:

$$v = \text{constant} \rightarrow a = 0 \rightarrow F_{net} = 0$$

$$F_{net} = 0 = F - W_x - F_f$$

$$F = F_f + W_x$$

$$W_x = 10000\,kg \times 10\,\frac{m}{s^2} \times \sin 8^\circ$$

$$W_x = 13\,917\ N$$

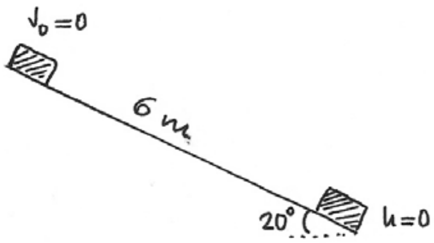
$$F_f = 6000\,N$$

$$F = 19917\ N$$

$$v = \frac{P}{F} = \frac{169\,280\,W}{19917\,N} \rightarrow \boxed{v = 8.5\,\frac{m}{s}}$$

2	**We let a body move down a slope of 20°. The mass of the body is 5 kg and the distance travelled is 6 m. The final velocity reached by the body (after travelling that distance) is 3 m/s. Use mechanical energies to find** **a) the coefficient of friction** **b) the total work by the forces on that body**

2



We will apply the conservation of mechanical energy:

$$\Delta E = E_f - E_i = W_{F,F_f}$$

The initial altitude is:

$$h = 6m \times \sin 20^\circ = 2.05\ m$$

The initial mechanical energy is:

$$E_i = PE_i + KE_i \xrightarrow{v_0=0} E_i = PE_i = 5\ Kg \times 10\frac{m}{s^2} \times 2.05\ m = 102.5\ J$$

The final mechanical energy is:

$$E_f = PE_f + KE_f \xrightarrow{h=0} E_f = KE_f = \frac{1}{2} \times 5\ Kg \times \left(3\frac{m}{s}\right)^2 = 22.5\ J$$

a) The work done by the friction force is

$$W_{F_f} = \Delta E = (22.5\ J - 102.5\ J) = F_f \times 6\ m \times \cos 180^\circ$$

The friction force is

$$-80\ J = -F_f \times 6\ m \longrightarrow F_f = 13.33\ N$$

The value of the coefficient of friction force

$$N = W_y = 5\ Kg \times 10\frac{m}{s^2} \times \cos 20^\circ = 46.98\ N$$

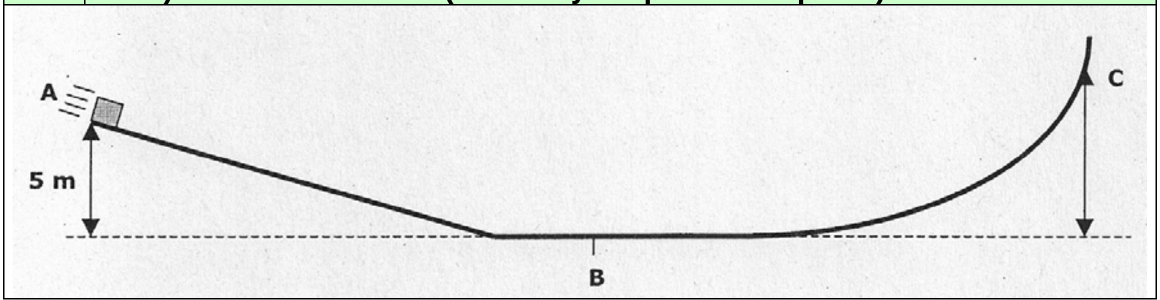
$$F_f = \mu \times N \longrightarrow \mu = \frac{F_f}{N} = \frac{13.33\ N}{46.98\ N} \rightarrow \boxed{\mu = 0.28}$$

b) The total work can be calculated applying the work-energy theorem:

$$W_{TOTAL} = \Delta KE \longrightarrow W_{TOTAL} = KE_f - \cancel{KE_i}^{0} \rightarrow$$

$$\rightarrow \boxed{W_{TOTAL} = 22.5\ J}$$

3	**The friction force in this exercise is negligible. If the initial speed of the body is 6 m/s, determine:** **a) the speed at B** **b) the altitude at C (the body stops at that point)**



③ We will apply the conservation of mechanical energy.

The mechanical energy at point "A" (initial) can be expressed as:

$$E_A = KE_A + PE_A = \frac{1}{2} m \left(6 \frac{m}{s}\right)^2 + m \cdot 10 \frac{m}{s^2} \cdot 5m =$$

$$= \left(18 \frac{m^2}{s^2}\right) m + \left(50 \frac{m^2}{s^2}\right) m = \left(68 \frac{m^2}{s^2}\right) m$$

ⓐ The speed at point "B"

$$F = 0;\ F_f = 0 \longrightarrow W_{F,F_f} = 0 \longrightarrow \Delta E = 0 \rightarrow E_{initial} = E_{final}$$

$$\boxed{E_A = E_B}$$

The mechanical energy at point "B" can be expressed as:

$$E_B = KE_B + PE_B \xrightarrow{h=0} E_B = KE_B = \frac{1}{2} \cdot m \cdot V_B^2$$

$$E_A = E_B \longrightarrow \left(68 \frac{m^2}{s^2}\right) m = \frac{1}{2} m V_B^2 \rightarrow$$

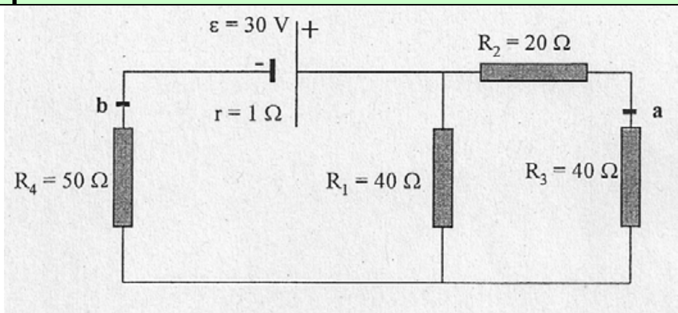
$$\rightarrow V_B = \sqrt{136 \frac{m^2}{s^2}} \longrightarrow \boxed{V_B = 11.66 \frac{m}{s}}$$

ⓑ The mechanical energy at point "C" can be expressed as:

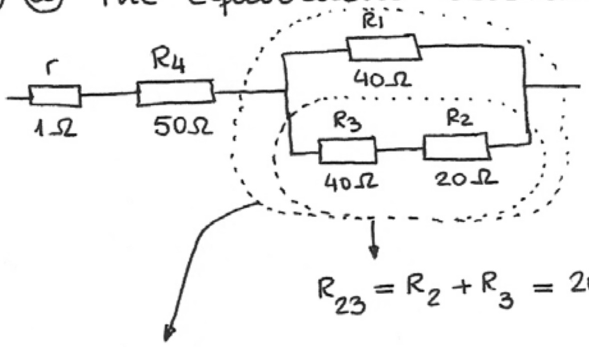
$$E_C = KE_C + PE_C \xrightarrow{V_C = 0} E_C = PE_C = m \cdot 10 \frac{m}{s^2} \cdot h$$

$$\boxed{E_A = E_C} \rightarrow \left(68 \frac{m^2}{s^2}\right) m = m \cdot 10 \frac{m}{s^2} \cdot h \rightarrow$$

$$\rightarrow h = \frac{68\ m^2/s^2}{10\ m/s^2} \longrightarrow \boxed{h = 6.8\ m}$$

4	**In this circuit, determine:** **a) the equivalent resistance** **b) the electric power supplied by the battery** **c) the potential difference between a and b**
	

④ ⓐ The equivalent resistance is



$$R_{23} = R_2 + R_3 = 20\,\Omega + 40\,\Omega = 60\,\Omega$$

$$R_{123} \rightarrow \frac{1}{R_{123}} = \frac{1}{R_1} + \frac{1}{R_{23}} = \frac{1}{40\,\Omega} + \frac{1}{60\,\Omega} = \frac{3+2}{120\,\Omega} = \frac{5}{120\,\Omega}$$

$$R_{123} = \frac{120\,\Omega}{5} = 24\,\Omega$$

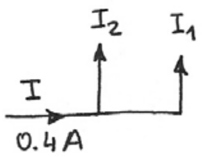
$$R_{equiv} = r + R_4 + R_{123} \longrightarrow \boxed{R_{equiv} = 75\,\Omega}$$

ⓑ Electric power of the battery

$$I = \frac{30\,V}{75\,\Omega} = 0.4\,A \longrightarrow P = \mathcal{E} \times I = 30\,V \times 0.4\,A$$

$$\boxed{P = 12\,W}$$

ⓒ Potential difference $V_a - V_b$



$$V_a - V_b = I \times R = 0.4\,A \times 50\,\Omega + I_1 \times 40\,\Omega$$

$$\begin{cases} I_1 + I_2 = 0.4\,A \\ 40\,\Omega \times I_2 = 60\,\Omega \times I_1 \rightarrow I_2 = 1.5 \times I_1 \end{cases}$$

$$I_1 + 1.5 \times I_1 = 0.4\,A$$

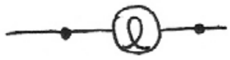
$$I_1 = \frac{0.4\,A}{2.5} = 0.16\,A$$

$$V_a - V_b = 0.4\,A \times 50\,\Omega + 0.16\,A \times 40\,\Omega$$

$$V_a - V_b = 20\,V + 6.4\,V \longrightarrow \boxed{V_a - V_b = 26.4\,V}$$

5	**A lamp has the following characteristics: 300 W of power and 220 V of potential difference. Determine:** **a) the resistance of the lamp** **b) the energy dissipated by the lamp in two months if that lamp works 4 hrs every day**

5 a



$$P = I^2 \times R \longrightarrow 300\ W = I^2 \times R$$

$$\Delta V = I \times R \longrightarrow 220\ V = I \times R$$

$$\frac{300\ W}{220\ V} = \frac{I^2 \times R}{I \times R} \rightarrow \frac{300\ W}{220\ V} = I \rightarrow I = 1.36\ A$$

$$220\ V = 1.36\ A \times R \longrightarrow R = \frac{220\ V}{1.36\ A} \Rightarrow \boxed{R = 162\ \Omega}$$

b Time

$$t = 2 \text{ months} \times \frac{30 \text{ days}}{1 \text{ month}} \times \frac{4\ h}{1 \text{ day}} \times \frac{3600\ s}{1\ h} = 864\,000\ s$$

Energy

$$E = 300\ \frac{J}{s} \times 864\,000\ s \times \frac{1\ Kw\text{-}h}{3\,600\,000\ J} \Rightarrow \boxed{E = 72\ Kw\text{-}h}$$