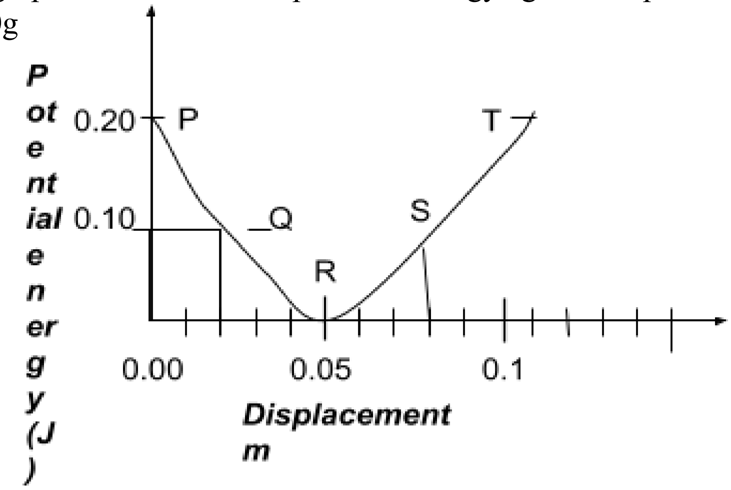
Work, energy and power

1. (a) State the law of conservation of energy

(b) The graph below shows the potential energy against displacements for a body of mass 80g



The body oscillates about point **R**. Calculate the velocity of the body at:

(i) **P** and **T**

(ii) **Q** and **S**

(iii) at **R**

(c) A wheel and axle are used to raise a load of 280N by a force 40N applied to the rim of the wheel. If the radii of the rim and axle are 70cm and 5cm respectively, calculate:

(i) The mechanical advantage

(ii) The velocity ratio

(iii) The efficiency

2. (a) A bicycle has wheels 66 cm in diameter. Its crank wheel has 44 teeth and the rear sprocket 16 teeth. The crank radius is 16.5 cm.

(i) Determine the radius of the rear sprocket.

(ii) The bicycle moves when the rear sprocket is made to move. Hence determine the velocity ratio.

(b) A man uses a block and tackle mechanism of velocity ratio 6 to lift a car engine smoothly through a height of 1 m in 5s. The man applies a force of 300N while the mass of the engine is 120 kg. Determine:

(i) The mechanical advantage of the pulley system.

(ii) its efficiency.

3. (a) Define work and state its S.I units

(b) A crane lifts a load 500kg through a vertical distance of 4m in 8 seconds. Determine:

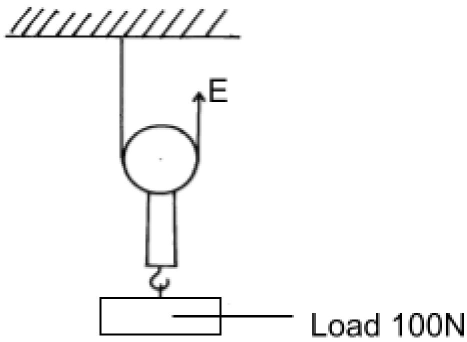
(i) Work done by the crane

(ii) Power developed by the crane

(iii) Efficiency of the crane given that it is operated by an electric motor rated 2.8Kw

(iv) State **two** effects which contribute to the efficiency being less than 100%

4. A load of 100N is raised using the system in the figure below by an effort.



Given that the efficiency of the machine is 90%, calculate the minimum effort.

Work, energy and power

1. (a) The law of conservation of energy states that the sum of kinetic energy and potential energy of a system is a constant

(b) (i) At P and T potential energy is a maximum and kinetic energy is a minimum. Hence velocity is zero (2mks)

(ii) At Q and S P.E has reduced by 0.1J. This equals the K.E

$K.E = \frac{1}{2} MV^2$

$0.1 = \frac{1}{2} \times 0.8V^2$

$0.1 = 0.4V^2$

$0.1 = V^2$

$V^2 = \frac{1}{4} = 0.25$

$V = 0.5m/s$

(iii) At R, auP.E has been converted to K.E velocity now is a maximum

So, $0.2 = \frac{1}{2} MV^2$

$\underline{0.4} = V^2$

$V = \sqrt{0.4}\ m/s$

$V = 0.64m/s$

(c) (i) $M.A = \frac{L}{E} = \frac{280N}{40N} = 7$ (2mks)

(ii) $V.R = \frac{P}{R} = \frac{70}{5} = 14$ (2mks)

(iii) $n = \frac{M.A}{V.R} \times 100\%$

$= \frac{7}{14} \times 100\%$

$= 50\%$ (2mks)

2. a) (i) $CR = \frac{\cancel{2\pi}R}{\cancel{2\pi}r} = \frac{\text{No of teeth draw}}{\text{No. of teeth of driven}}$ ✓1

$\therefore \frac{16.5\ cm}{r} = \frac{44}{16}$

$r = \frac{16.5\ cm \times 16}{44}$ ✓1

$R = 6\ cm$ ✓1

(ii) $V.R. = \frac{R}{r}$ ✓1

$= \frac{16.5\ cm}{6\ cm}$ ✓1

$= \underline{\underline{2.75}}$ ✓1

b) (i) $M.A. = \frac{L}{E}$ $120kg \times 10N/kg = 1200N$ ✓1

$$= \frac{1200N}{300N} \quad 1$$

$$= 4 \quad 1$$

(ii) Its efficiency of:

$$D = \frac{M.A \times 100\%}{V.R.} \quad 1$$

$$= \frac{4 \times 100\%}{6}$$

$$= 66.67\% \quad 1$$

3. (a) Work is said to be done when the body on which a force is applied moves in the direction of force; S.I unit if the Joule, J or (Nm);

(b) (i) Work done = P.E gained ;

= mgh

= 500 x 4 x 10;

= 20,000J;

(ii) $$\text{Power} = \frac{\text{work done}}{\text{time taken}}$$

$$= \frac{20{,}000}{8}$$

= 2.5KW ; or (2500 watts);

(iii) $$\text{Efficiency} = \frac{\text{work output}}{\text{work input}} \times 100;$$

$$= \frac{2.5}{2.8} \times 100;$$

= 89.29%;

(iv) – Friction between movable parts

- Sound due to moving parts
- - heat –some of the electrical energy is converted to unnecessary heat

Work, energy and power

1. Given that a lamp is rated 45W 240V. Calculate the resistance of the heating element.
2. An electric bulb is rated 40W, 240V. What is the resistance of its filament?

3. An electrical immersion heater is rated 3kW, 250V. Choose a suitable fuse from 3A, 5A, 10A,
   12A, and 20A that can be used in such an appliance.

4. An electric kettle is rated 3KW, 250V. Determine the resistance of the coil

5. An electric kettle rated 3.0Kw, 240V is filled with water. If the water boiled after 8 minutes
   of heating, determine the energy used in boiling the water.

6. (a) An electrical heater is rated 3.45KW. The heater is immersed in 2.4kg of water.
   Calculate the minimum time it takes for the temperature of the water to rise from 23.0°C to 69.0°C. *(Specific heat capacity of water = 4.2Jg^{-1}K^{-1})*

Work, energy and power

1. $D = 1V$

$I = \frac{P}{V}$

$= \frac{45}{240}$ 1 mk

$= 0.1875A$

$P\ I^2R$

$R = \frac{P}{I^2}$

$= \frac{45}{(0.1875)^2}$ 1 mk

$= \frac{45}{0.03515} = 1280\Omega$ 1 mk

2. $P = \frac{V^2}{R}$

$R = \frac{(240)^2}{40}$ √

$= 1440\Omega$ √

3. $\frac{P}{V} = I$

$\frac{3000}{250} = 12A$

suitable fuse 13A

4. *An electric kettle is rated 3KW, 250V. Determine the resistance of the coil*

$P = IV = \frac{V2}{R}$

$300 = \frac{2502}{R}$

$R = \frac{62500}{3000}$

$= 20.83\ \Omega$

5. *Energy* E_1 = *Power x time*

$= 3000 \times 8 \times 60$

$= 1440000J$ 1

6. $= 2.4 \times 4.2Jg^{-1}K^{-1} \times 46K$ (1mk)

$= 2.4 \times 4200JKg^{-1}\ K^{-1} \times 46K$ (1mk)

$= 463\ 6805J$

Let the rime be t

Energy $H = Pt = 3450W \times t$

$$3450t = 463\ 680J$$
$$t = 134.4s$$