Chapter 5: Work, Energy and Power

- Work
- Energy conversion and conservation
- Potential energy and kinetic energy
- Power

a. **Show an understanding of the concept of work in terms of the product of a force and displacement in the direction of the force.**

b. **Calculate the work done in a number of situations including the work done by a gas which is expanding against a constant external pressure: $W = p\Delta V$.**

Work Done by a force is defined as the product of the force and displacement (of its point of application) in the direction of the force

ie $\mathbf{W = F\,s\cos\theta}$

Negative work is said to be done by *F* if *x* or its compo. is anti-parallel to *F*

If a variable force F produces a displacement in the direction of F, the work done is determined from the **area under F-x graph**. {May need to find area by "counting the squares". }

c. **Give examples of energy in different forms, its conversion and conservation, and apply the principle of energy conservation to simple examples.**

By Principle of Conservation of Energy,

Work Done on a system =
KE gain + GPE gain + Thermal Energy generated {ie Work done against friction}

d. **Derive, from the equations of motion, the formula $E_k = \frac{1}{2}mv^2$.**

Consider a rigid object of mass m that is initially at rest. To accelerate it uniformly to a speed v, a constant net force F is exerted on it, parallel to its motion over a displacement s.

Since F is constant, acceleration is constant,

Therefore, using the equation:

$$v^2 = u^2 + 2as,$$
$$as = \frac{1}{2}(v^2 - u^2)$$

Since kinetic energy is equal to the work done on the mass to bring it from rest to a speed v,

The kinetic energy, E_K = Work done by the force F

$= Fs$

$= mas$

$= \frac{1}{2}m(v^2 - u^2)$

e. **Recall and apply the formula $E_k = \frac{1}{2}mv^2$.**

Self-explanatory

f. **Distinguish between gravitational potential energy, electric potential energy and elastic potential energy.**

Gravitational potential energy: this arises in a system of *masses* where there are attractive gravitational forces between them. The gravitational potential energy of an object is the energy it possesses by virtue of its position in a gravitational field.

Elastic potential energy: this arises in a system of atoms where there are either attractive or repulsive short-range inter-atomic forces between them. (From Topic 4, E. P. E. = $\frac{1}{2}kx^2$.)

Electric potential energy: this arises in a system of *charges* where there are either attractive or repulsive

	electric forces between them.
g.	**Show an understanding of and use the relationship between force and potential energy in a uniform field to solve problems.**
	The potential energy, U, of a body in a force field {whether gravitational or electric field} is related to the force F it experiences by: $\mathbf{F = -\frac{dU}{dx}}$.
h.	**Derive, from the defining equation W = Fs the formula E_p = mgh for potential energy changes near the Earth's surface.**
	Consider an object of mass m being lifted vertically by a force F, without acceleration, from a certain height h_1 to a height h_2. Since the object moves up at a constant speed, F is equal to m g. The ***change*** in potential energy of the mass = Work done by the force F = F s = F h = m g h
i.	**Recall and use the formula E_p = mgh for potential energy changes near the Earth's surface.**
	Self-explanatory
j.	**Show an appreciation for the implications of energy losses in practical devices and use the concept of efficiency to solve problems.**
	Efficiency: The ratio of (useful) output energy of a machine to the input energy. ie $= \frac{\text{Useful Output Energy}}{\text{Input Energy}} \times 100\ \% = \frac{\text{Useful Output Power}}{\text{Input Power}} \times 100\ \%$
k.	**Define power as work done per unit time and derive power as the product of force and velocity.**
	Power {instantaneous} is defined as the work done per unit time. P $= \frac{\text{Total Work Done}}{\text{Total Time}}$ $= \frac{W}{t}$ Since work done W = F x s, P $= \frac{F \times s}{t}$ = **F v** - for object moving at <u>const speed</u>: F = Total resistive force {equilibrium condition} - for object beginning to <u>accelerate</u>: F = Total resistive force **<u>+ ma</u>** {N07P1Q10,N88P1Q5}