CHAPTER NINE
ENERGY AND ENERGY TRANSFAR

System and Environment

System is a small portion of the universe.
System boundary: its an imaginary surface that divides the universe into the system and the environment surrounding the system.
Example: imagine a force applied to an object in empty space. We can define the object as a system. The force applied to it is an influence on the system from the environment that acts across the system boundary.

Work done by a constant force

The work done on the system (figure-1)
$W = F.\Delta r.\cos\theta$
* if $\theta = 90$ then $w = 0$
* work is scalar quantity and its unit is (Joul = N.m).
* work is an (energy transfer). If the work is positive, energy is transferred to the system. If the work is negative, the energy is transferred from the system.

The scalar product of two vectors

The scalar product is often called the (dot product) because of the dot symbol.
$A.B = (A)(B)(\cos\theta)$

Example: The vectors (A) and (B) are given by ($A = 2i + 3j$) and ($B = -1i + 2j$).
(a) determine the scalar product A.B?
(b) Find the angle (θ) between A and B?

Work done by a varying force

$W = \Sigma F_x.\Delta x$
Example: A force acting on a particle varies with (x) as shown in figure. Calculate the work done by the force as the particle moves from (x=0 to x=6 m)?
Solution:
Total work done = (5*4) N + (0.5*2*5) N = 25 J.

Work done by a spring:

A model of a common physical system for which the force varies with position is shown in figure below. If a spring is either stretched or compressed a small distance from its (equilibrium) configuration, it exerts on the block a force that can be expressed as

$\mathbf{F_s = -k.x}$

x: the position of the block relative to its equilibrium (x=0)

k: spring constant

* The force required to stretch or compress a spring is proportional to the amount of stretch or compress (x).this force law for spring is known as (Hook's law).

* The value of (k) is measure of the stifness of a spring.

* Stiff spring have a large (k), soft spring have a small (k).

* The unit of (k) is (N/m).

The work done by an applied force on a block-spring system between arbitrary positions of the block is:

$\mathbf{W_{app} = \int F_{app}\, dx = \int k_x\, d_x = (1/2)\,(k_{xf})^2 - (1/2)\,(k_{xi})^2}$

Example: A common technique used to measure the force constant of a spring is as shown in figure-8. The spring is hung vertically, and an object of mass (m) is attached to its lower end. Under the action of (load = mg), the spring stretches a distance (d) from its equilbrium position. (a) If a spring is stretched (2 cm) by a suspended object having a mass of (0.55 kg). What is the force constant of the spring? (b) How much work is done by the spring as it stretches through this distance?