Elastic Force

For elastic strings or springs that obey Hooke's Law:

$$F = kx$$

Elastic Potential Energy

$$E = \frac{1}{2}kx^2$$

Or

Area under an F-X Graph.

In general, a deformed material may not obey Hooke's Law. If the proportional limit (but not the elastic limit) is exceeded, the EPE stored in the spring can still be evaluated using area under the F-x graph.

If a material is stretched and then allowed to relax, it may follow two different curves fir increasing and decreasing stress. The work done by the material when it returns to its original shape is less than the work done by the external force to deform andwiched area represents the heat lost due to hysteresis.

Contact Forces: an oscillation motion whose acceleration is directly proportional to the displacement from its equilibrium point, and is always directed towards that point or is in opposite direction to displacement.

Pressure due to Fluid (liquid or gas): is the force acting per unit area by the fluid on a body submerged at a depth in the fluid. The difference in pressure between 2 points in a fluid separated by depth *h* is given by:

$$\Delta p = \rho h g$$

Upthrust or Buoyant Force: is the upward force exerted by a fluid on a body submerged in the fluid.

Archimedes' principle states that Upthrust acting on an object is equals to the weight of the fluid displaced.

$$U = \rho V g$$

For an object floating in equilibrium in a fluid **(Principle of Flotation)**

$$Weight\ of\ object\ =\ Upthrust$$

Drag/ Viscous Forces

- Force resisting an object moving relative to a fluid (e.g. air resistance)
- Always opposes motion
- Magnitude is dependent on the velocity of object

For laminar (streamline) flow of fluid,

$$Drag\ Force\ =\ kv$$

Non-Contact Forces

- Gravitational force between masses
- Electric force between charges
- Magnetic force between currents

Conditions for Static Equilibrium of a Rigid Body

1. **Translational equilibrium:** The **net external force** acting on the body is zero.

$$\sum F = 0$$

2. **Rotational equilibrium:** The **net torque** on the body about **ANY point** is zero.

$$\sum \tau = 0$$

For a 3-force system in Static Equilibrium

The 3 forces must form **a closed vector triangle**.

For an **extended body** in static equilibrium, the lines of action of the 3 forces must also **intersect at a common point** unless the 3 forces are parallel.

Turning Effects of Forces

Moment of a force about a point (the pivot) is the **product** of the magnitude of the force and the **perpendicular distance** of the **line of action** of the force to the point.

A ***couple*** is a pair of forces which are equal in magnitude and opposite in direction, whose line of action do not coincide.

Torque of a couple is the **product** of the **magnitude of one of the forces** of the couple and the **perpendicular distance** between the forces.

Centre of Gravity of a body is the point at which the weight of the body appears to act.