Mechanical system

Mechanical systems are of two types,

(i) Translational mechanical system and

(ii) Rotational mechanical system.

The motion takes place along a straight line is known as translational motion.

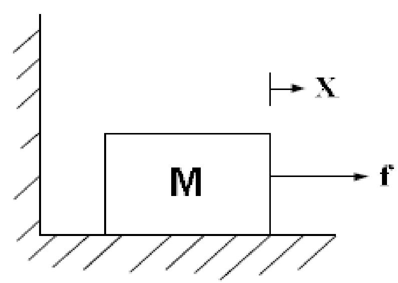
The rotational motion of a body can be defined as the motion of a body about a fixed axis.

Translational mechanical system

There are three basic elements in a translational mechanical system,
(a) Mass
(b)spring
(c) Damper

Mass: A mass is denoted by M. If a force *f* is applied on it and it displays distance *x*, then

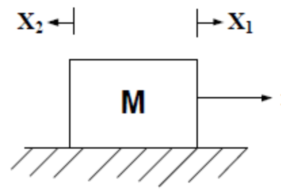
$$f = M\frac{d^2x}{dt^2}$$



Force applied on a mass with displacement in one direction

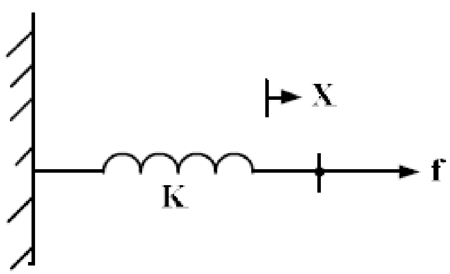
If a force f is applied on a **mass M** and it displays distance *x1*in the direction of f and distance *x2* in the opposite direction, then

$$f = M\left(\frac{d^2x_1}{dt^2} - \frac{d^2x_2}{dt^2}\right)$$



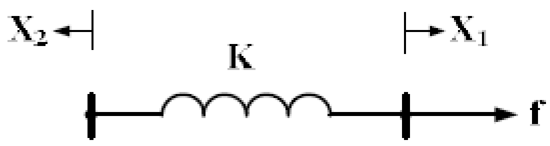
Force applied on a mass with displacement two directions

(b) **Spring:** A spring is denoted by K. If a force f is applied on it and it displays distance x, then $f = Kx$ as shown



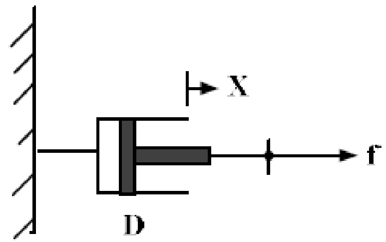
Force applied on a spring with displacement in one direction

If a force f is applied on a springK and it displays distance $x_1$in the direction of f and distance x_2 in the opposite direction, then
$f = K\ (x_1 - x_2\ )$as shown in Fig



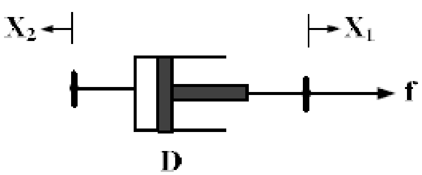
Force applied on a spring with displacement in two directions

Damper: A damper is denoted by D. If a force f is applied on it and it displays distance x, then $f = D\frac{dx}{dt}$ as shown in Fig.



Force applied on a damper with displacement in one direction

If a force f is applied on a damperD and it displays distance x_1 in the direction of f and distance x_2 in the opposite direction, then $f = D\left(\frac{dx_1}{dt} - \frac{dx_2}{dt}\right)$ as shown in Fig.



Rotational mechanical system

There are three basic elements in a Rotational mechanical system, i.e. (a) inertia, (b) spring and (c) damper.

(a) **Inertia:** A body with aninertia is denoted by J. If a torque$T$ is applied on it and it displays distanceΘ, then $T = J\dfrac{d^2\theta}{dt^2}$. If a torque$T$ is applied on a body with inertia J and it displays distance Θ_1 in the direction of T and distance Θ_2 in the opposite direction, then $T = J\left(\dfrac{d^2\theta_1}{dt^2} - \dfrac{d^2\theta_2}{dt^2}\right)$.

(b) **Spring:** A spring is denoted by K. If a torque$T$ is applied on it and it displays distanceΘ, then $T = K\theta$. If a torque$T$ is applied on a body with inertia J and it displays distance Θ_1 in the direction of T and distance Θ_2 in the opposite direction, then $T = K(\theta_1 - \theta_2)$.

(c) **Damper:** A damper is denoted by D. If a torque$T$ is applied on it and it displays distanceΘ, then $T = D\dfrac{d\theta}{dt}$. If a torque$T$ is applied on a body with inertia J and it

displays distance Θ_1 in the direction of T and distance Θ_2 in the opposite direction, then $T = D\left(\dfrac{d\theta_1}{dt} - \dfrac{d\theta_2}{dt}\right)$.

Force-voltage Analogy

Translational	Rotational	Electrical
Force (f)	Torque (T)	Voltage (v)
Mass (M)	Inertia (J)	Inductance (L)
Damper (D)	Damper (D)	Resistance (R)
Spring (K)	Spring (K)	Elastance (1/C)
Displacement (x)	Displacement (Θ)	Charge (q)
Velocity (u) = $\dot{x}$	Velocity (u) = $\dot{\theta}$	Current (i) = $\dot{q}$

Force-current analogy

Translational	Rotational	Electrical
Force (f)	Torque (T)	Current (i)
Mass (M)	Inertia (J)	Capacitance (C)
Damper (D)	Damper (D)	Conductance (1/R)
Spring (K)	Spring (K)	Reciprocal of Inductance (1/L)
Displacement (x)	Displacement (Θ)	Flux linkage (ψ)
Velocity (u) = $\dot{x}$	Velocity (u) = $\dot{\theta}$	Voltage (v) = $\dot{\psi}$