PhyzGuide: Rotational Dynamics I

translational	FORCE	rotational

Name Force

Symbol F (or $\mathbf{F}$ vector)

Defn Defined by Newton's second law:

$\sum F = ma$ ($\sum \mathbf{F} = m\mathbf{a}$)

Force is what causes linear acceleration—change in linear velocity.

Name Torque

Symbol τ (τ vector)

Defn Torque is the rotational version of force. It causes angular acceleration—change in angular velocity. It is defined algebraically as:

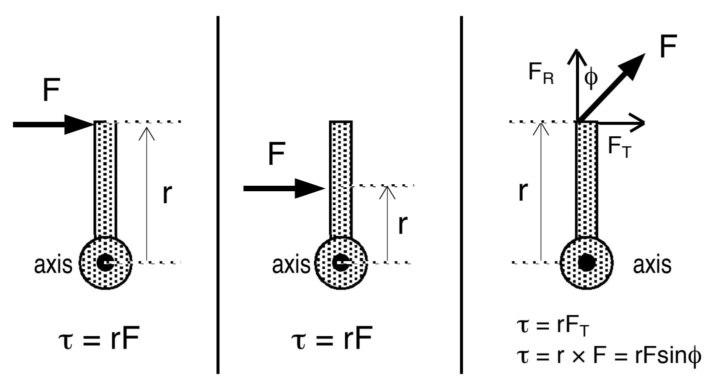
$\tau = rF\sin\phi = rF$ when $\mathbf{r} \perp \mathbf{F}$.

$r \equiv$ The *distance* from the axis of rotation to the point through which the force is acting. (Notice that a force exerted at a point far from the axis of rotation produces a greater torque than the same force exerted near the axis.) This distance is sometimes called the **lever arm**, or **torque arm**.

$F \equiv$ The quantity of linear *force* acting.

$\phi \equiv$ The *angle* between the radial direction and the direction of force.

NOTE: F_T is the component of force in the TANGENTIAL direction, F_R is the component of force in the RADIAL direction.



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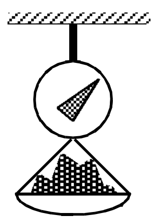
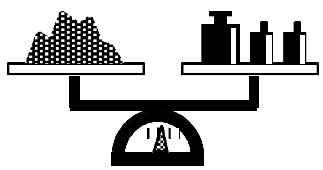
translational — INERTIA — rotational

translational

Name Mass
Symbol m
Defn A measure of resistance to change in linear velocity.
HOW TO FIND IT:
Gravitational Method: Weigh the object and calculate mass via the relation $W = mg$
Inertial Method: Inertial balance



spring scale

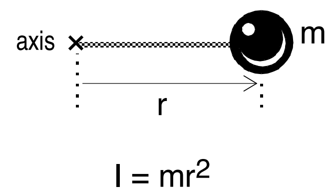


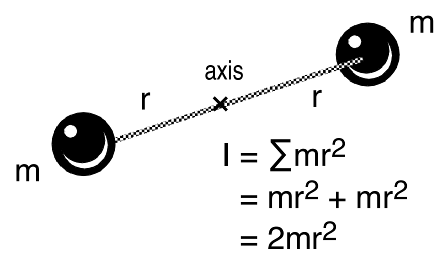
equal arm balance

GRAVITATIONAL METHODS

rotational

Name Rotational Inertia, also Moment of Inertia
Symbol I (capital "i")
Defn A measure of resistance to change in angular velocity.
HOW TO FIND IT:
In general, $I = \sum mr^2$. For a point mass m, rotating at a distance r from an axis, $I = mr^2$. (This distance is called the **moment arm.**) Solid objects vary—use tables giving I in terms of total mass M and radius R of an object.





translational — NEWTON'S LAWS — rotational

translational

NEWTON'S FIRST LAW
Bodies maintain their state of rest or of constant speed in a straight line unless acted on by an unbalanced external force.

NEWTON'S SECOND LAW
Acceleration is proportional to net force and inversely proportional to mass:
$\sum \mathbf{F} = m\mathbf{a}$.

NEWTON'S THIRD LAW
"For every force there is an equal and opposite reaction force." Forces always come in equal and opposite pairs.

rotational

NEWTON'S FIRST LAW
Bodies maintain their state of rest or of constant angular speed in the same plane unless acted on by an unbalanced external torque.

NEWTON'S SECOND LAW
Angular acceleration is proportional to net torque and inversely proportional to rotational inertia: $\sum \tau = I\alpha$.

NEWTON'S THIRD LAW
"For every torque there is an equal and opposite reaction torque." Torques always come in equal and opposite pairs.

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