Chapter#1

Force , energy and work

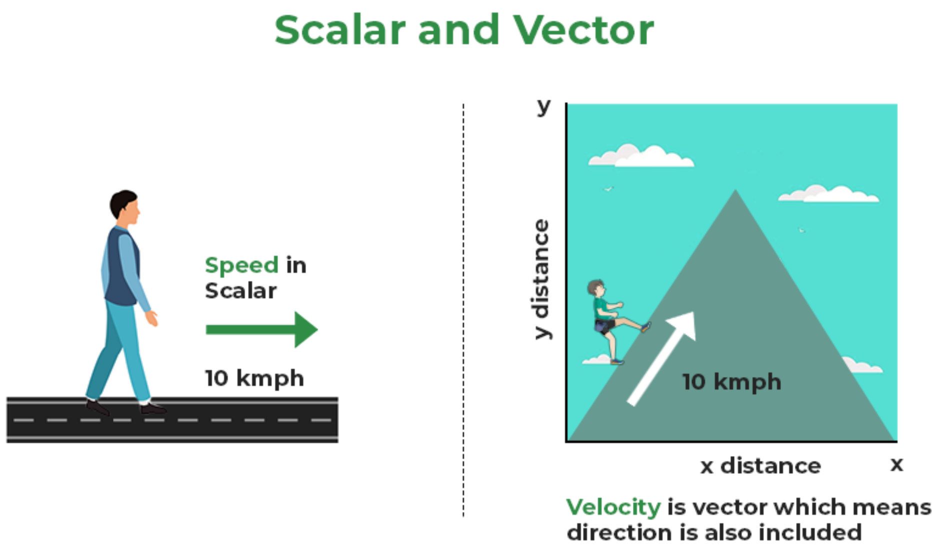
We will discuss :-

- Quantities.
- Adding vector.
- Newton’s law of motion .
- Uniform circular motion .
- work .
- Energy .

Quantities

Physics deal with many physical quantities, which are divided into scalar and vector

- Scalar: quantity has magnitude (size) only .
- Vector: quantity has magnitude and direction .



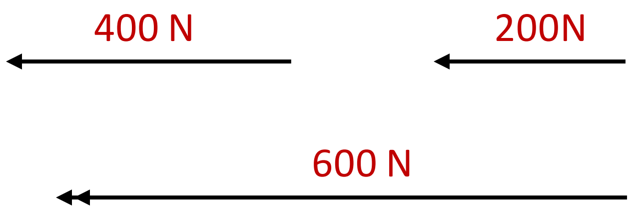
Scalar	Vector
Distance	Displacement
Mass	Velocity
Speed	Force
Temperature	Acceleration
Charge	Momentum
Volume	Weight

Adding vectors

- A line and an arrow can represent a vector.
- The length of the line, drawn to scale, represents the magnitude of the vector and the arrow shows the direction.
- The sum of two or more vectors is called resultant .
- It is shown as a double arrow.

Adding vectors

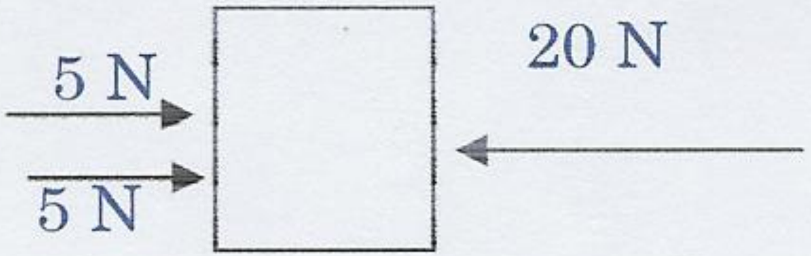
- An example of vector addition is adding forces.

i)When the forces are in the same direction they are added.	ii)When the forces are in opposite directions they are subtracted.
	

Exercise

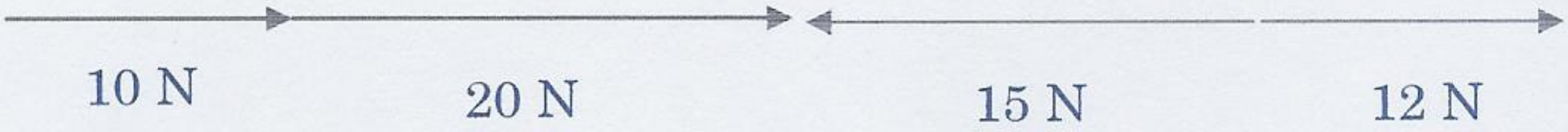
1. Find the resultant of the following.

(a)



(b)

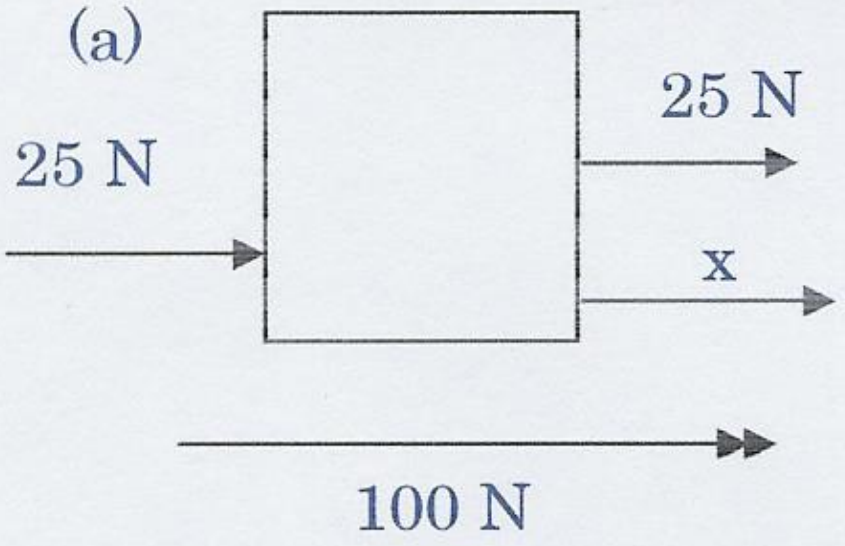
2.



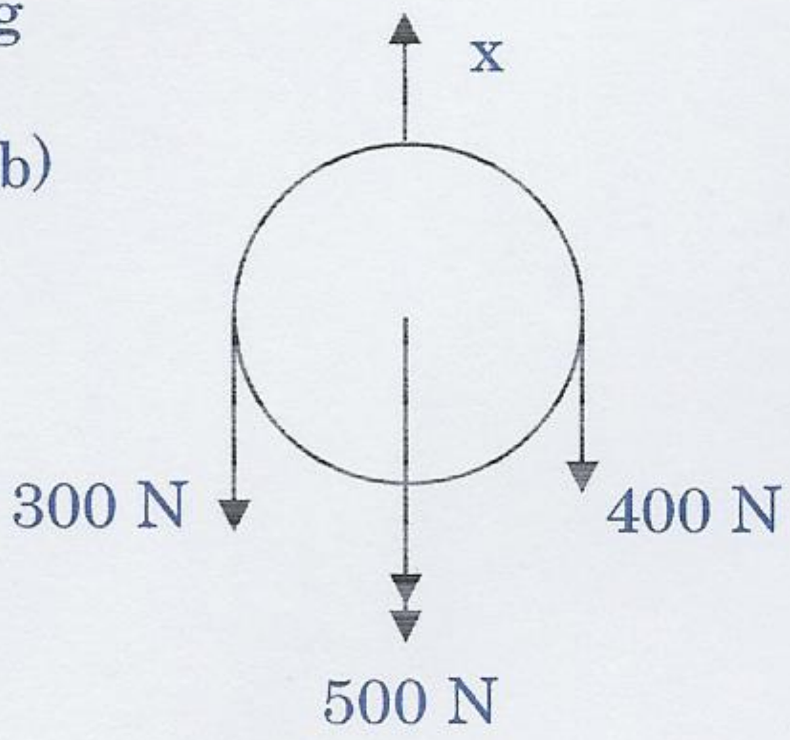
Exercise

3. Find the missing vector for the following

(a)



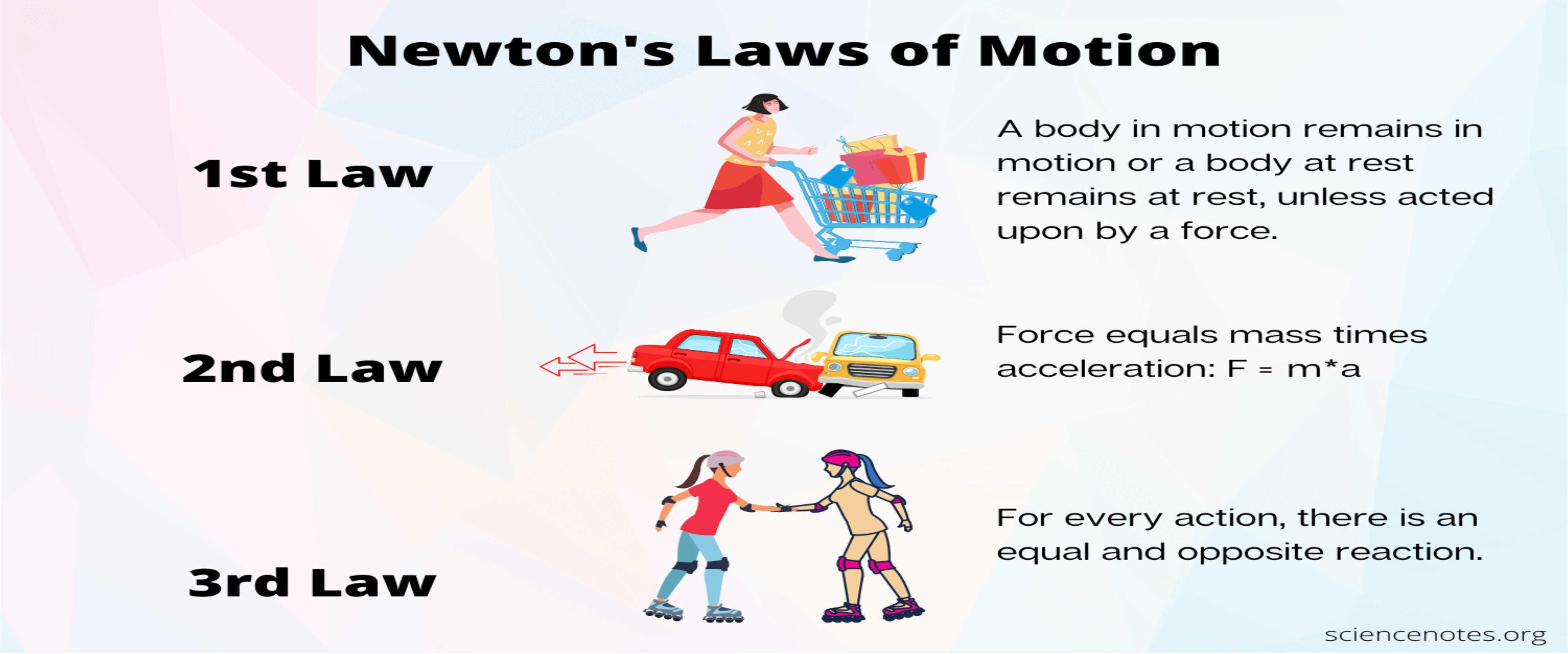
(b)



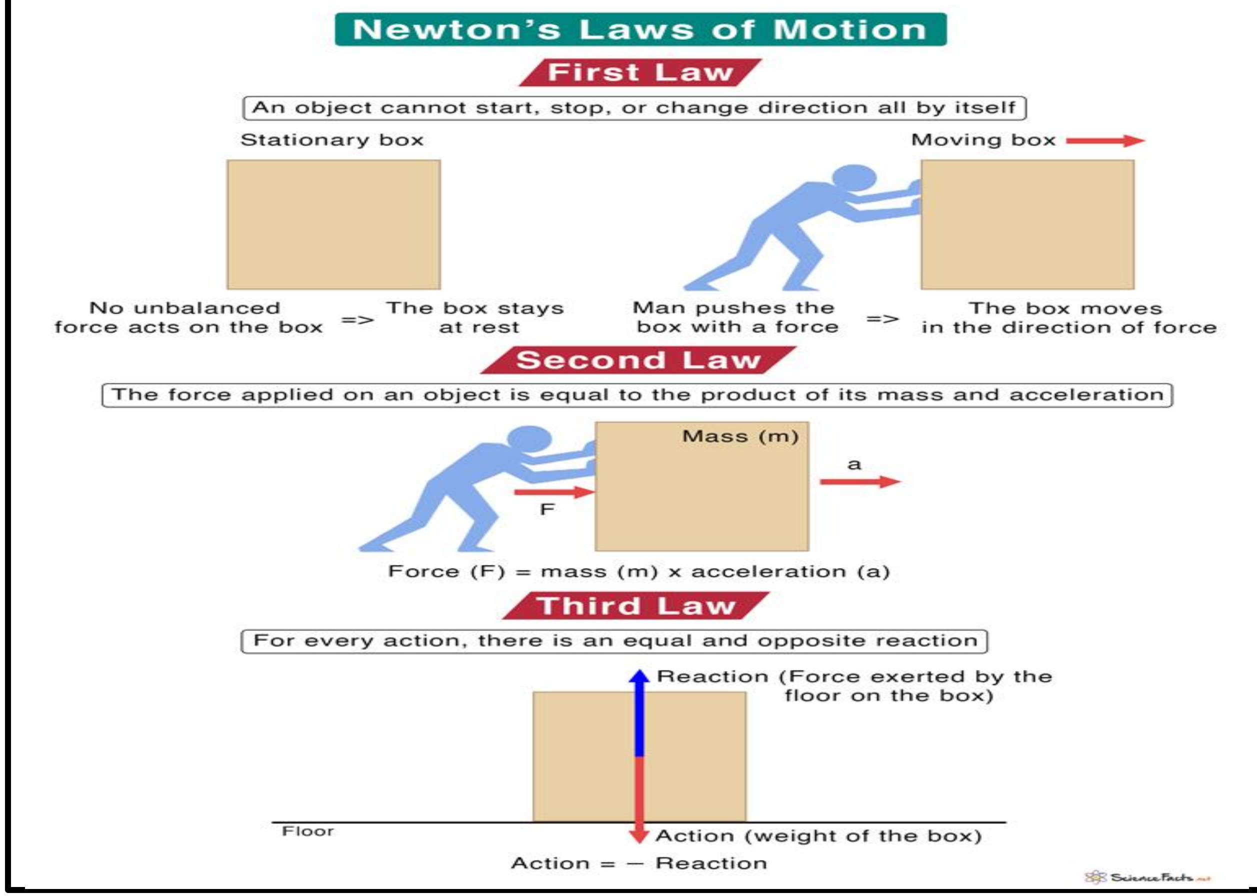
Newton’s Laws of Motion

- If the sum of all external forces on an object is zero, then its speed and direction will not change. Inertia
- If a nonzero net force is applied to an object its motion will change $F= ma$
- In an interaction between two objects, the forces that each exerts on the other are equal in magnitude and opposite in direction.

Newton’s Laws of Motion



Newton’s Laws of Motion



Uniform Circular Motion

When the speed of a point moving in a circle is constant, its motion is called uniform circular motion

To simplify the description of circular motion, we concentrate on angles instead of distances.

Instead of displacement, we speak of angular displacement Δθ

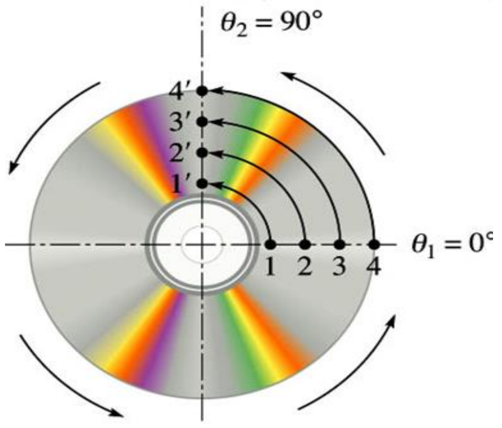
. Definition of angular displacement: $\boxed{\Delta\theta = \theta_f - \theta_i}$

. The average angular velocity : $\boxed{\omega = \frac{\Delta\theta}{\Delta t}}$

. The unit rad/s

Where the radian measure of an angle of 360°

$360° = 2\pi$



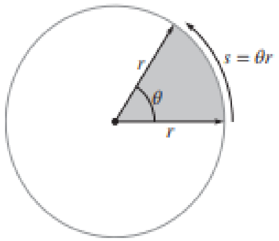
(a)

Circular to Linear

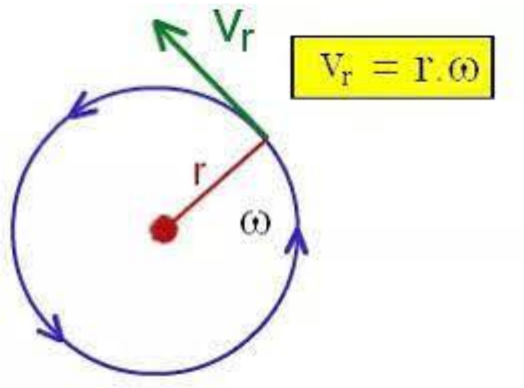
. Displacement $\Delta s = r\Delta\theta$

Where θ in rad

. Speed $|v|=\frac{\Delta s}{\Delta t} = \frac{r\Delta\theta}{\Delta t}$ =rω



.The direction of the velocity vector v is tangent to the circular path



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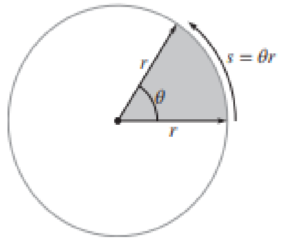

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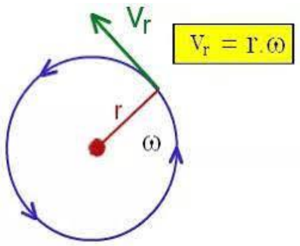


.The frequency(f)of the motion, which is the number of revolutions per unit time.

.The time for the point to travel completely around the circle is called the period of the motion,
(T)

$f = \frac{1}{T}$ = $\frac{2\pi}{\omega}$

Where The SI unit for frequency is the hertz (Hz)

Merry-Go-Round ACT

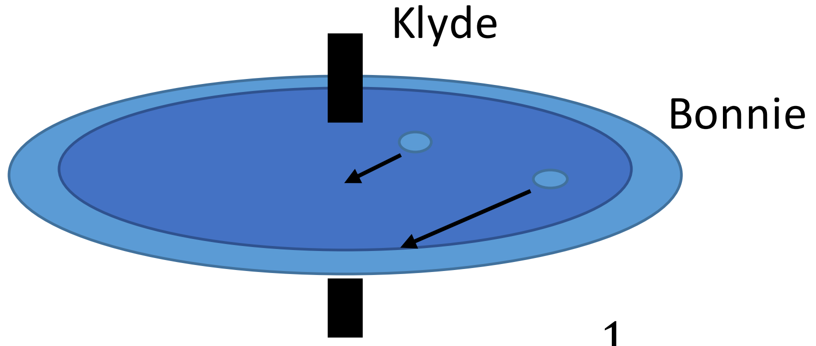
- Bonnie sits on the outer rim of a merry-go-round with radius 3 meters, and Klyde sits midway between the center and the rim. The merry-go-round makes one complete revolution every two seconds.

-Klyde's speed is :

(a) **the same as Bonnie's**

(b) **twice Bonnie's**

(c) **half Bonnie's**



$$V_{Klyde} = \frac{1}{2} V_{Bonnie}$$

Bonnie travels $2\pi R$ in 2 seconds $v_B = 2\pi R / 2 = 9.42$ m/s

Klyde travels $2\pi (R/2)$ in 2 seconds $v_K = 2\pi (R/2) / 2 = 4.71$ m/s

Merry-Go-Round ACT

- Bonnie sits on the outer rim of a merry-go-round with radius 3 meters, and Klyde sits midway between the center and the rim. The merry-go-round makes one complete revolution every two seconds.

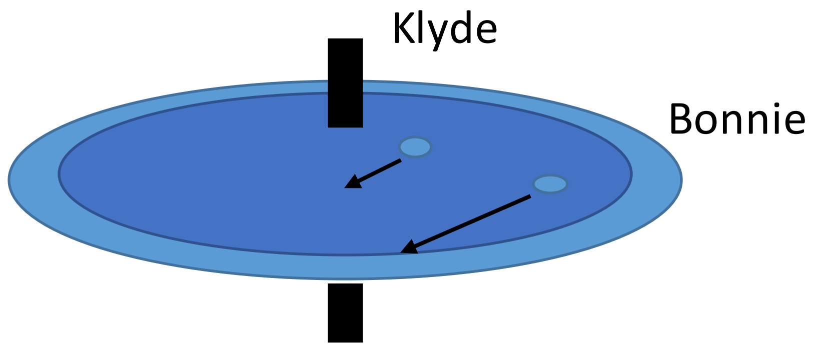
-Klyde's angular velocity is :

(a) the same as Bonnie's

(b) twice Bonnie's

(c) half Bonnie's

The angular velocity w of any point on a solid object rotating about a fixed axis is the same.
Both Bonnie & Klyde go around once (2p radians) every two seconds.



Example

Example 5.2

Speed in a Centrifuge

A centrifuge is spinning at 5400 rev/min. (a) Find the period (in seconds) and frequency (in hertz) of the motion. (b) If the radius of the centrifuge is 14 cm, how fast (in meters per second) is an object at the outer edge moving?

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Strategy 5400 rev/min *is* the frequency, but in a unit other than hertz. After a unit conversion, the other quantities can be found using the relations already discussed.

Solution (a) First convert the frequency to hertz:

$$f = 5400 \frac{\text{rev}}{\text{min}} \times \frac{1 \text{ min}}{60 \text{ s}} = 90 \text{ rev/s}$$

The frequency is $f = 90$ Hz $= 90$ s^{-1}. The period is

$$T = 1/f = 0.011 \text{ s}$$

(b) To find the linear speed, we first find the angular speed in radians per second:

$$|\omega| = 2\pi f = 2\pi \frac{\text{rad}}{\text{rev}} \times 90 \frac{\text{rev}}{\text{s}} = 180\pi \text{ rad/s}$$

The linear speed is

$$v = |\omega| r = 180\pi \text{ s}^{-1} \times 0.14 \text{ m} = 79 \text{ m/s}$$

Discussion Notice that much of this problem was done with unit conversions. Instead of memorizing a formula such as $|\omega| = 2\pi f$, an understanding of where the formula came from (in this case, that 2π radians correspond to one revolution) is more useful and less prone to error.

Practice Problem 5.2 Clothing in the Dryer

The drum of a clothes dryer spins at 51.6 rev/min. If the radius of the drum is 30.5 cm, how fast is the outer edge of the drum moving?

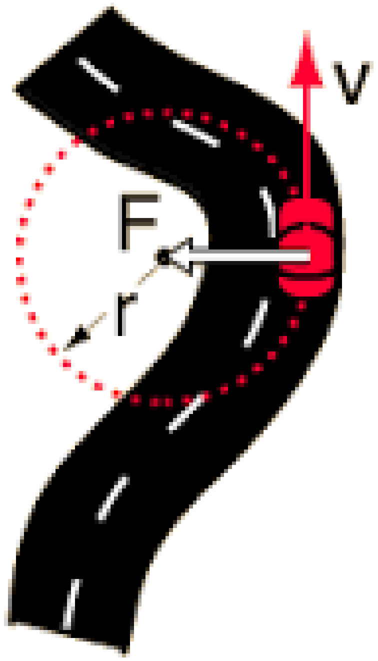
Centripetal force

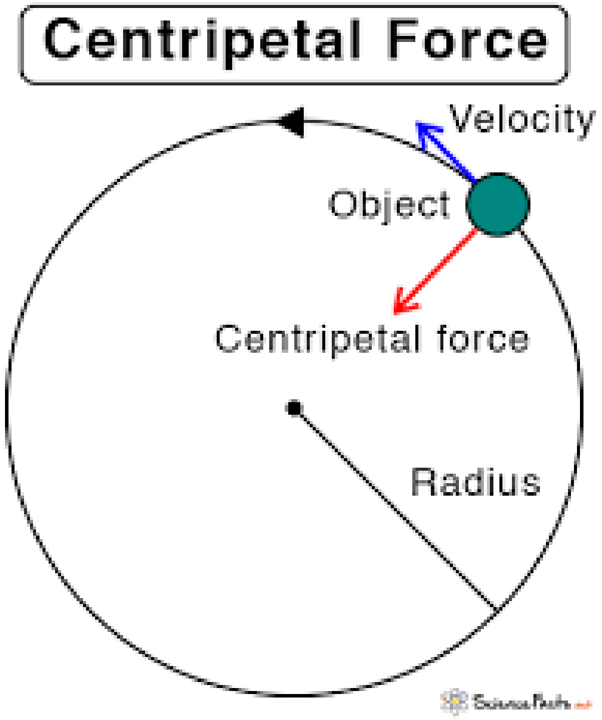
- Centripetal force is defined as the force acting on a body that is moving in a circular path that is directed toward the center around which the body moves. The term comes from the Latin words *centrum* for "center" and *petere*, meaning "to seek."
- How to Calculate Centripetal Force ?
- $\boldsymbol{F_c = \frac{mv^2}{r}}$

Centripetal force

$$F_{centripetal} = m\frac{v^2}{r}$$

$\frac{v^2}{r}$ is the centripetal acceleration





Centripetal force

- An object(m = 8Kg) is performing circular motion with a radius of 2m. If the velocity of the object is 10 m/s, find the centripetal force acting on the object.

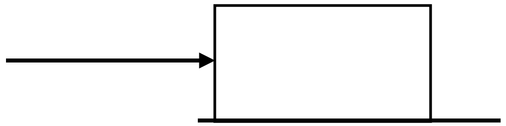
Centripetal force

- An object(m = 1Kg) is performing circular motion with a radius of 4m. If the centripetal force acting on the object is 100N, find the velocity of the object. .

Work

- **Work:** **the force that acts times the distance moved in the direction of force.**
- **Units of work** $W = F.d = N.m = Joule(J)$
- **Example 1: A force of 50N acts on a box and moves it 3m**

W= $50.3 = 150\ J$



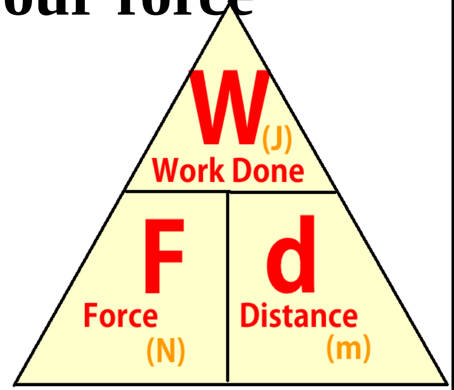
- **Example 2:If you lift an object of mass 4kg upwards for 2m your force**

your work $W = Fd$

$= mgd$

$= 4 \times 9.8 \times 2$

$= 78.4\ J$



Energy

- Energy: the ability to do work.
- Energy is measured in Joule
- Types of energy: electrical nuclear, heat, chemical…etc
- Two main types of energy in mechanical

 - Kinetic energy (KE)

 - Potential energy (PE)

Energy

- Kinetic energy (KE) :the energy in the body due its motion
- KE=$\frac{1}{2}mv^2$
- Example

*Find KE of a mass 4kg moving with speed 30 m/s

$$KE = \frac{1}{2} mv^2$$

$$= \frac{1}{2} \times 4 \times 900 = 1800 \text{ J}$$

- KE is never negative.
- KE can be rotational.

Kinetic Energy

Kinetic energy is the energy that objects possess due to their motion.

$$KE = \frac{1}{2}mv^2$$

m = mass (kg)
v = velocity (m/s)
KE = Kinetic energy (J)

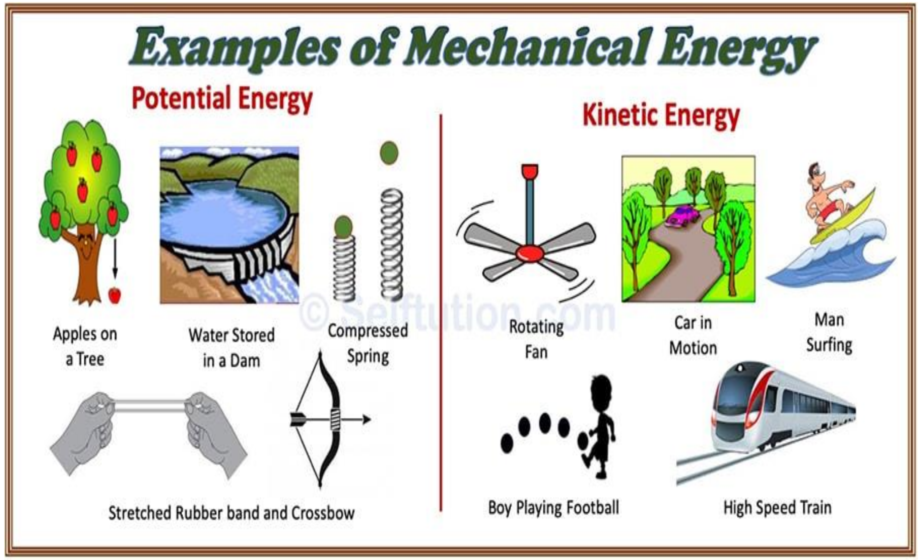
Energy

- Potential energy (PE) : energy due to an object's position or configuration.
- PE=mgh

e.g: compressed spring- Object at a certain height- stretched rubber band

- Example: an object at height 5m with mass 3 kg find its Potential energy ?

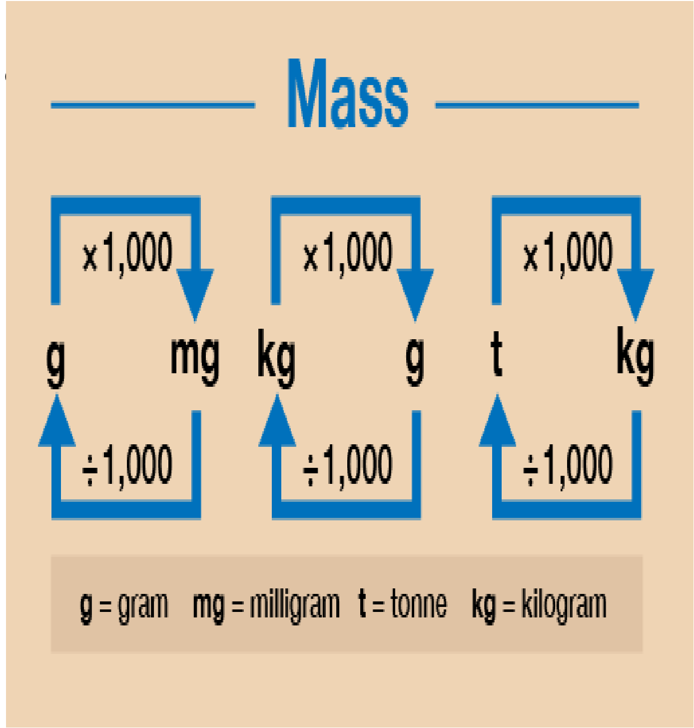
$$PE = mgh$$
$$= 3\times 9.8 \times 5 = 147\ J$$



Energy

A free falling object with $m = 5$ kg has a speed of 4 m/s at height $h = 2$m. Find the total energy of the object at this height?

Converting units



Selected Prefixes

Factor	Prefix	Symbol
10^{3}	kilo-	k
10^{-1}	deci-	d
10^{-2}	centi-	c
10^{-3}	milli-	m
10^{-6}	micro-	μ
10^{-9}	nano-	n
10^{-12}	pico-	p