Body at rest

When a body does not change its position, with respect to its surroundings, it is said to be at rest.

Body at motion

When a body changes its position, with respect to its surroundings, it is said to be in motion. The motion may be linear if the body moves in a straight line or it may be circular when it moves in a curved path.

Terms relating to motion

Displacement

When a body is in motion from one place to another, the displacement is the distance from the starting position to the final position.

Speed

It is the rate of change of displacement of a body in motion. It has got no direction and it is a scalar quantity.

Speed = distance travelled per unit time $\frac{s}{t} = \frac{(\text{Distance})}{\text{Time}}$

Unit = m/s, km/Hr.mile/Hr.

Velocity

It is the rate of change of displacement of a body in motion in a given direction. It is a vector quantity and can be represented both in magnitude and direction by a straight line. Velocity may be linear or angular. The unit of linear velocity is metre/sec,

Velocity = $\frac{S}{t} = \frac{\text{Displacement}}{\text{Time}}$

Unit = m/s, km/Hr,mile/Hr.

Difference between speed & velocity

Speed	Velocity
The rate of change of place of an object is its speed.	The speed in a definite direction is called velocity.
In the speed, direction is not indicated. Only the magnitude is expressed.	Both the magnitude and direction are expressed.
Speed $= \frac{\text{Distance covered}}{\text{Time}}$	Velocity $= \frac{\text{Distance in definite direction}}{\text{Time}}$

Acceleration

Rate of change of velocity is known as acceleration or it is the change of velocity in unit time. Its unit is metre/sec^2. It is a vector quantity.

$a = \frac{\text{change in velocity}}{\text{Time}}$ m/sec^2

unit = m/s^2 (metre per square second)

u = Initial velocity in metre per second(m/sec)

v = Final velocity in metre per second(m/sec)

s = Distance in metre (m)

t = Time in second (sec)

a = Acceleration m/sec^2 (positive value)

R = Retardation m/sec^2 (negative value of acceleration)

Equations of motion

Then $v = u + at$

$s = ut + \frac{1}{2}at^2$ and $v^2 - u^2 = 2as$

$v^2 = u^2 + 2as$

Retardation

When the body has its initial velocity lesser than its final velocity it is said to be in acceleration. When the final velocity is lesser than the initial velocity the body is said to be in retardation. Then the three equation of motion will be

$v = u - at$

$s = ut - at^2$

$u^2 - v^2 = 2as$

Average speed

Vm - Average speed in metre/min, (metre/sec)

n - Revolutions per minute or number of strokes per minute

s - Distance travelled, length of stroke.

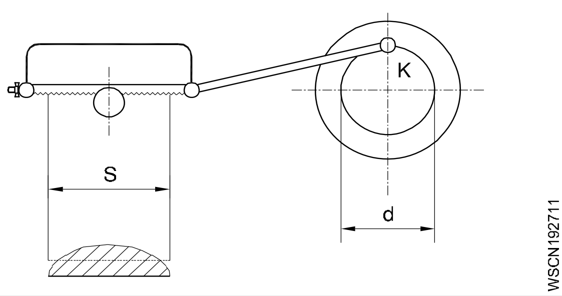
Stroke speed (Fig 1)

For one revolution of the point k, of the crank pin the distance the power saw blade moves = 2 x s

Therefore 'n' revolutions in a minute the distance = 2 x s x n. Since the stroke of the blade will be given in metre to determine the average speed

Vm = 2 x s x n

Fig 1



Piston speed (Fig 2)

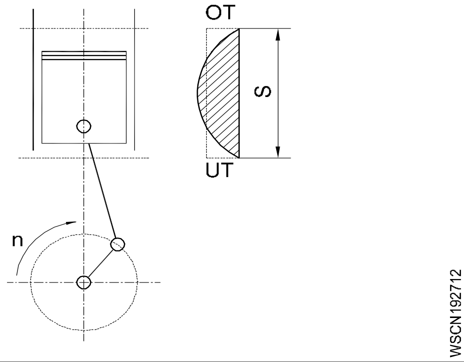
As the piston moves backward and forward, its speed constantly changes between the upper and lower dead centres. Hence in this case also the average speed Vm =

2 x s x n. Since s is expressed in mm and n in number of revolutions/per minute and since Vm is given in metre/sec, we have

$$Vm = 2 \times s \times \frac{n}{1000} \text{ metre/min.}$$

$$= \frac{2xsxn}{1000x60} \text{ m/sec}$$

Fig 2



If s is given in metres then

$$\mathbf{Vm = 2 \times s \times \frac{n}{60} = s \times \frac{n}{60} \text{ metre/sec.}}$$

2 x s denotes a double stroke.

In case of the reciprocating motion the average speed is taken into account for calculations.

Vm = 2 x s x n metre/min if s is given in metres

Example (Fig 3)

An extrusion press has a crank radius of 20 cm and an rpm of 30/min. Calculate the average speed in metre/min, metre/sec.

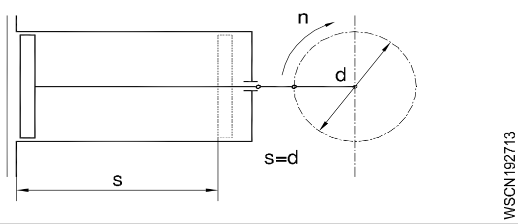
s = The diameter = 40 cm.

One crank revolution makes the piston to travel in 2s=80cm

$$Vm = 2 \times 400 \times \frac{30}{1000} \text{ metre/min.}$$

= 24 metre/min = 0.4 metre/sec

Fig 3



NEWTON'S LAWS OF MOTION

Equations of motions under gravity

Upward	**Downward**
$V = u - gt$	$v = u + gt$
$s = ut - \frac{1}{2}gt^2$	$s = ut + \frac{1}{2}gt^2$
$u^2 - v^2 = 2gs$	$v^2 - u^2 = 2gs$

Motion under gravity

A body falling from a height, from rest, has its velocity goes on increasing and it will be maximum when it hits the ground. Therefore a body falling freely under gravity has a uniform acceleration. When the motion is upward, the body is subjected to a gravitational retardation. The acceleration due to gravity is denoted with 'g'.

Momentum

It is the quantity of motion possessed by a body and is equal to the product of its mass, and the velocity with which it is moving. Unit of momentum will be kg metre/sec.

Momentum = mass x velocity

Newton's laws

First law

Every body continues to be in a state of rest or of uniform motion in a straight line unless it is compelled to change that state of rest or of uniform motion by some external force acting upon it.

Second law

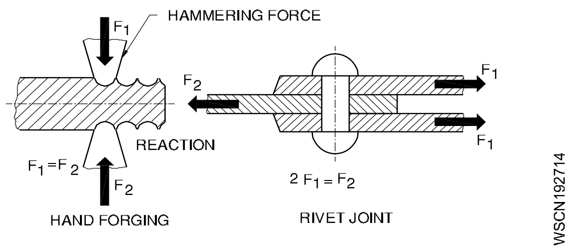
The rate of change of momentum of a moving body is directly proportional to the external force acting upon it and takes place in the direction of the force.

Third law

To every action there is always an equal and opposite reaction.

In the rivet joint equal forces act on the strap and they opposite force F_2. (Fig 4)

Fig 4



Law of conservation of momentum

When two moving bodies have an intentional or unintentional impact, then sum of the momentum of the bodies before impact = sum of the momentum after impact, or the change in momentum after the impact is zero.

m_1 - mass of one body and

v_1 - velocity with which it moves

m_2 - mass of second body

v_2 - velocity with which it moves

Momentum = m x v= mass of the body x its velocity

Rate of change of momentum = force acting on the body

$$m\left(\frac{(V-u)}{t}\right) = F$$

force = mass x acceleration

Momentum of two bodies before impact = momentum after impact

$m_1 \times v_1 + m_2 \times v_2 = (m_1 + m_2)V$

Terms - Some Examples in vehicles

Displacement

The piston displacement is the space between 2 dead centres (TDC and BDC) where in the piston moves in the cylinder. (Fig 5)

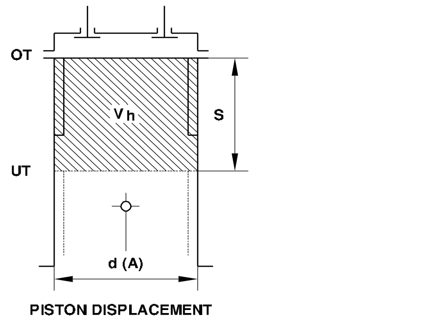


Fig 5

PISTON DISPLACEMENT

Speed

This is reckoned in 2 ways in a vehicle

– Vehicle speed in kmh/mph

– Engine speed in rpm

Velocity

A motor vehicle, normally changes its speed and direction on road. Hence used in velocity calculation.

Acceleration (Fig 6)

When the speed of the vehicle is increased on road, it is said to be accelerated.

Deceleration (Fig 6)

Deceleration or Retardation (this is further explained)

During the application of brakes of a vehicle the speed of the vehicle is decreased. Then it is said to be decelerated or retarded.

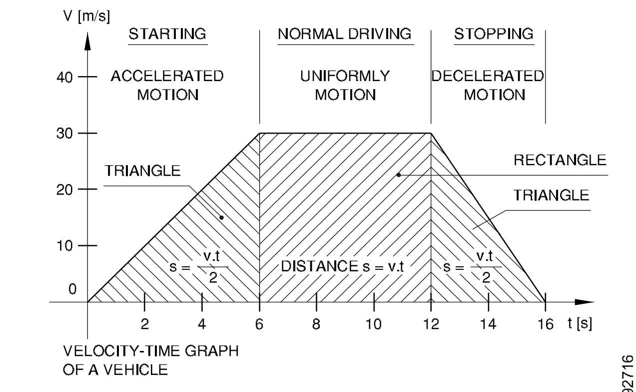


Fig 6

THE GRAPHICAL REPRESENTATION OF THE ACCELERATION AND DECELERATION

Circular or Angular motion (Fig 7)

When a body rotates about an axis, it is said to have angular motion or circular motion.

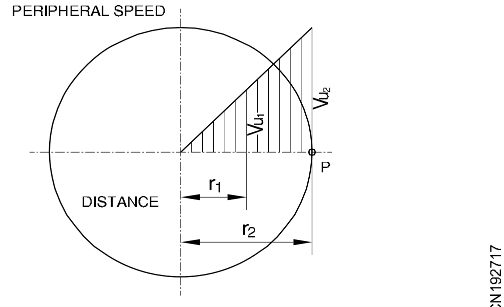


Fig 7

CIRCULAR MOTION

Example

In circular motion bodies (like shafts, axles, gear-wheels, pulleys, flywheels, grinding wheels) turn with constant speed around its axis.

The angular of circular motion is also called Angular velocity or Peripheral speed.

Expressed in Metre/sec or Radians per second.

Bodies at rest and in motion

Terms related to brake system

Every vehicle has a brake system. When brakes are applied on a moving vehicle (with certain velocity) its velocity is reduced and vehicle is decelerated and it stops at a certain distance. So the definition of the terms related to Brake application are set forth below.

Deceleration (a) (Fig 8)

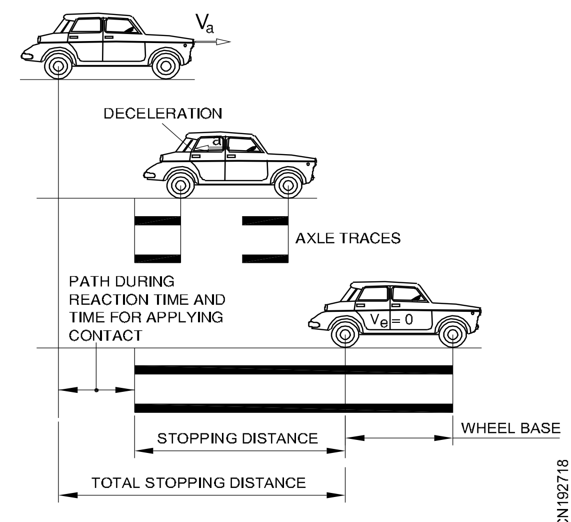


Fig 8

DECELERATION, DECELERATION TIME, TOTAL STOPPING DISTANCE

This is the decrease in velocity within a certain time. e.g A car travelling at 90 kmph stops after 10 Sec.

The deceleration = $90 \times \frac{1000}{3600} \times 1/10$

= 25 m/s/10 sec

= 2.5 m/sec^2

Deceleration time

The time 10 seconds is called the above time to stop the vehicle.

Stopping distance

During the deceleration time the car travels a distance called i.e Stopping distance 'd'.

But the total stopping distance is reckoned as equal to normal stopping distance and distance travelled by the car during reaction time of the driver.

The reaction time is explained as below

During the application of brakes, the driver takes sometime to recognise the danger and then apply the brakes. The time (thus elapsed) is called reaction time. During this time the vehicle travels some more distance before coming to a stop. So the total stopping distance actually varies due to the reaction time of the driver and it is longer than the normal stopping distance. The reaction time varies between driver to driver.

Example

A car is travelling with a speed of 72 kmph and its acceleration (a) = 5 m/sec^2. The reaction time of driver to apply brakes is 1.5 seconds. calculate the total stopping distance.

Solution

Velocity of car = 72 kmph

$$\left(1\,\text{kmph} = \frac{1000\text{ m}}{3600\text{ sec}} = \frac{5}{18}\text{ m/sec}\right)$$

= 20 m/sec

acceleration = 5 m/sec^2

$$\text{Normal stopping distance } S = \frac{V^2}{2a}\ (\text{m}) = \frac{(20)^2}{2(5)} = 40$$

Total stopping distance

= 40 metre + Velocity x Reaction time

= 40 m + (20 x 1.5) m

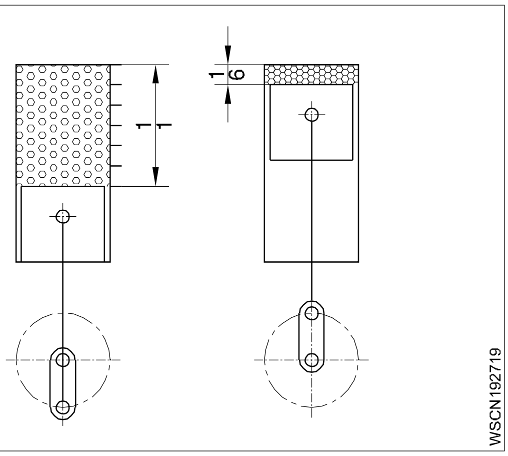
= 70 metres.

Newon's Law of Motion

Some Examples in vehicles

First law (with examples) (Fig 9)

Fig 9



Bodies at rest or in Uniform motion

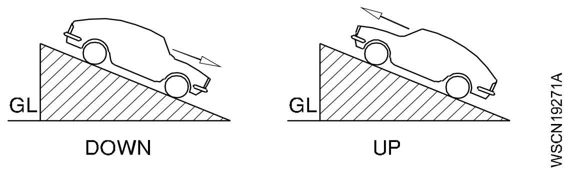
The diesel engine piston remains at rest at TDC or BDC due to its inertia. Expansion of gas pressure or flywheel momentum moves the piston from TDC or BDC.

Second law (with examples) (Fig 10)

The rate of change of momentum of a moving body (say Engine part or Vehicle)is directly proportinal to external force acting take place in the direction of force.

- A connecting rod in motion is brought to rest at BDC.
- The direction of movement of a vehicle is altered by force of wind.
- When a vehicle travels in a down gradient its speed increases.
- The speed of vehicle is decreased when travelling up gradient.

Fig 10



Third law (with examples) (Fig 11&12)

Fig 11

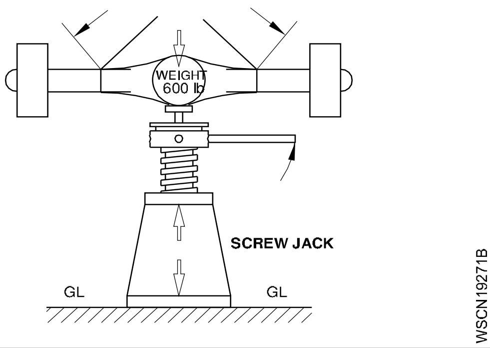
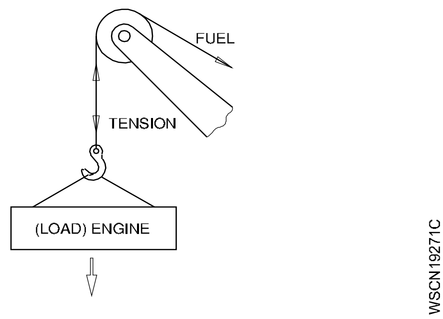


Fig 12



To every action there is always an equal and opposite reaction.

All upward force = All downward forces

– Jack is lifting a differential

– Crane rope is lifting an engine.

Examples

- A body travels a distance of 168 metres in a straight line in 21 secs. What velocity the body is travelling.

  Velocity = distance travelled/time

  = 168 metres/21 secs

  = 8m/sec

- A train covers a distance of 150 kilometres, between two stations, in 2 1/2 hours. Determine the average velocity with which the train is moving.

  Average velocity = Distance travelled/time taken

  = 150 Km/2 1/2 hrs = $\frac{150}{\frac{5}{2}} = 150 \times \frac{2}{5}$ Km/hr

  = 60 Km/hr

- A vehicle accelerates uniformly from a velocity of 8 km/hr to 24 km/hr in 4 secs. Determine the acceleration and the distance travelled by it during that time.

  Initial velocity = 8 km/hr (u)

  Final velocity = 24 km/hr (v) $a = \frac{v - u}{t}$ m/sec^2

  time = 4 sec (t) acceleration (a)

  ∴v = u + at

  24 km/hr = 8 km/hr + a x 4 sec

  (24km/hr - 8km/hr - 16km/hr)

  ∴ 4a sec = 16 km/hr = 16000 metre/3600 sec

  ∴ acceleration (a) = 16000 metre/3600 x 4 sec^2

  4a = 4.44

  Acceleration (a) = 1.1 metre/sec^2

  Distance travelled (4a) = 4 x 1.1m = 4.4 m

- A car moving with a velocity of 50 km/hr is brought to rest in 45 secs. Find out the retardation.

  Initial velocity = 50 km/hr (1km= 1000 metres)

  Final velocity = 0 km/hr (1 Hour = 3600 seconds)

  Time = 45 secs

  v = u – at 50km/hr x $\frac{5}{18}$ m/sec = 13.88 m/sec

  0 = u – at

  u = at $a = \frac{v}{t} = \frac{13.88 \text{ m/sec}}{45 \text{ sec}} = 0.3 \text{m/sec}^2$

  50000/3600 metre/sec = a x 45 sec

  ∴Retardation = 50000/3600 x 45 metre/sec^2

  = 0.30 metre/sec^2

- A body falling freely under the action of gravity reaches the ground in one second. Determine the height from which the body fell. Take g = 9.81 metre/sec^2.

  Initial velocity = 0 metre/sec (U)

  Acceleration due to gravity = 9.81 metre/sec^2 (g)

  Time taken = 1 sec (t)

  = ut + $\frac{1}{2}$ gt^2 0 x 1 sec= $\frac{1}{2}$ x 9.81 m/sec^2 x 1^2 sec

  = 0 x 1 sec + $\frac{1}{2}$ x 9.81 metre/sec^2 x 1 sec^2

  1 Sec^2 = 4.905 metres. s = 4.905 metres

- A force of 30 N acts on a body at rest. The mass of the body is 50 kg. Determine the velocity of the body after 4 secs, the distance it covers during that period and the acceleration

  F = m x a

  30 N = 50 kg x a

  3 kg x metre/sec^2 = 50 kg x a

  ∴ acceleration = 3/50 metre/sec^2

  = 0.06 metre/sec^2 a = 0.06 m/sec^2

  v = u + at

  = 0 + 0.06 metre/sec^2 x 4 sec = 0.24 metre/sec

  s = ut + 1/2 at^2 = 0 + 1/2 x 0.06 metre/sec^2 x 16 sec^2

  = 0.48 metre s = 0.48 metre

- A stone is thrown vertically upwards with a velocity of 120 metre/sec. Determine (a) the maximum height to which it travels before starting to return to earth. (b) The total time taken by the stone to go up and come down. (c) The velocity with which it will strike the ground.

  Initial velocity of throw = 120 metre/sec (u)

  Final velocity = 0 metre/sec (v) (taken g = 10 m/sec^2)

  Retardation due to gravity = 10 metre/sec^2

  u^2–v^2 = 2g.s

  ∴ 120^2 metre^2/sec^2 – 0 = 2 x 10 metre/sec^2 x s

  ∴ s = 120 x120/2 x 10 metre = $\frac{120 \times 120}{2 \times 10}$

  = 720 metre

  when it comes down its velocity at start = 0 metre/sec.

  The acceleration due to gravity = 10 metre/sec^2 and the distance travelled = 720 metre

  ∴ v^2– u^2 = 2as v^2-0 = 2x 10 m/sec^2 x 720 m

  v^2– 0 = 2 x 10 x 720 metre^2/sec^2 $v = \sqrt{14400} \text{ m}^2/\text{sec}^2$

  ∴ v = 120 metre/sec

  Time taken to go up and reach a velocity of 0 metre/sec = u/g = 120 metre/sec/10 metre/sec^2 = 12 sec.

  Time taken to start from rest and attain a velocity of 120 metre/sec = v/g = 12 sec.

  ∴ Total time taken = 24 sec.

- Calculate the Angular velocity in radian/second of an engine flywheel when it is rotating at 2800 rpm. (Fig 1 & 2)

  Angular velocity (W) = This is the rate of change of displacement or angle turned through per unit time.

  Solution

  Angular velocity of flywheel W= $2\pi N/60$ rad/sec. [N = 2800 rpm]

  = 2π x 2800/60 radian/sec.

  = 293.3 radian/sec.

Fig 1

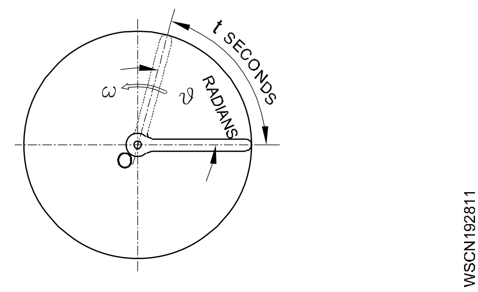
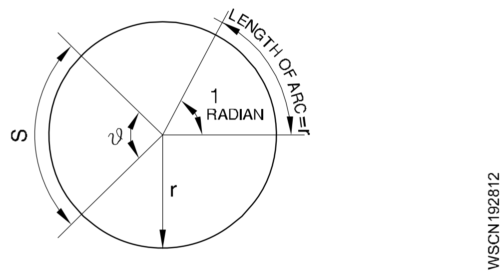


Fig 2



- A motor car road wheel of dia 540 mm turns through an angle of 120°. Calculate the distance moved by a point on tyre thread of the wheel.

  Solution

  There are 2π radians in one turn of wheel. i.e 2π radians = 360°

  Since wheel turns 120° angle, 120° = 120 x 2π/360

  = 2.094 radians

  Distance moved by a point on tyre S – re

  [where r = 270 mm

  θ = 2.094 radian]

  S = 270 x 2.094 mm

  = 565.38 mm

  Circumferential distance moved by the point = 565.38 mm

- The rear wheels of a car have diameter of 600 mm. The rear axle makes 250 rpm. Find out the peripheral speed of rear wheels in m/sec.

Solution

$$\text{Peripheral speed V} = \frac{\pi dN}{1000} \times \frac{1}{6} \text{(m/s)}$$

$$= \frac{3.14 \times 600}{60} \times \frac{250}{1000} = 7.85 \text{ m/sec}$$

- Calculate the stopping distance of a car travelling with a speed of 72 km/h and being accelerated with a - 5 m/ sec^2.

  Solution

  Va (initial speed of a car) = 72 kmph

  $$(1\text{ kmph} \times \frac{1000}{3600}\text{ m/sec}) = 72\ \frac{5}{18}\text{ m/sec}$$

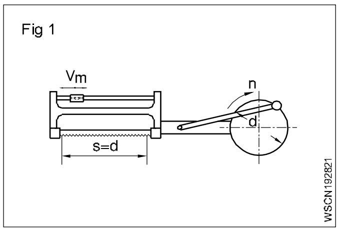
  = 20 metres/sec

  $$\text{Stopping distance S} = \frac{Va^2}{2a} \text{ (metre)}$$

  $$= \frac{20^2}{2 \times 5} = \frac{400}{10}$$

  $= 40$metre

Assignment

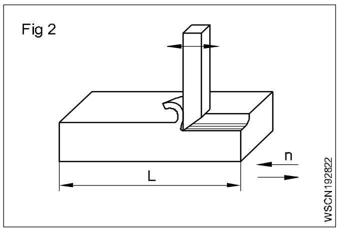
1 

S = 180 mm

n = 65 (double stroke)

Vm = _____metre/min

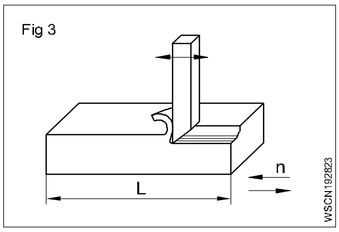
Vm is average cutting speed)

2 

V = 16 metre/min

s = 210 mm

n = ______

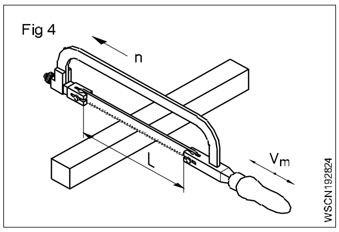
3 

(V is the cutting speed)

n = 22 strokes (Double stroke)/min

V = 18 metre/min

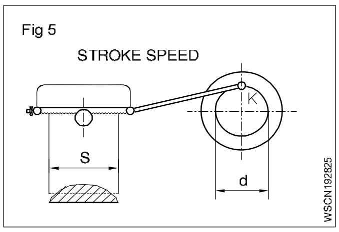
s = ______ mm

4 

s = 240 mm

n = 30 (working stroke)

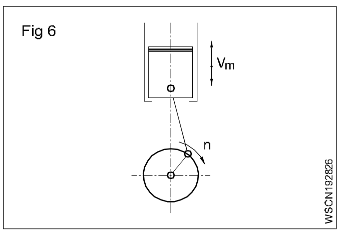
V = ______ metre/min

5 

n = 50 cutting strokes

V = 32 metre/min

d = ______ mm

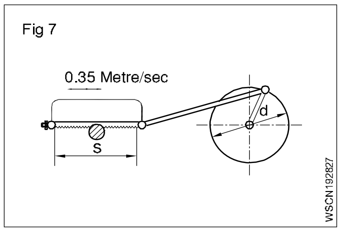
6 

s = 64 mm

n = 3600 rpm

Vm = _____metre/sec

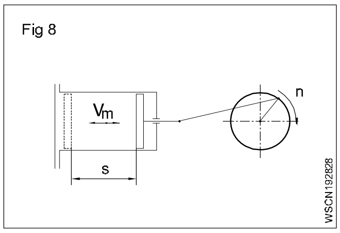
Vm is the average piston speed)

7 

Vm = 0.35 metre/sec

s = 200 mm

n = ______ rpm

8 

s = 650 mm

Vm = 90 metre/min

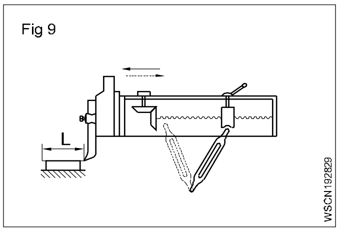
n = ______ rpm

9 Vm_1 = 5.2 metre/sec

Increased to

Vm_2= 6.3 metre/sec

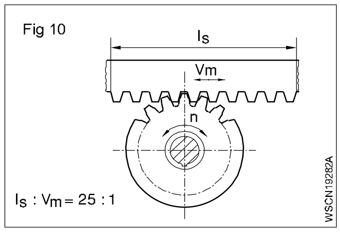
Increase in n (rpm) = ______ %

10 

s = 250 mm

n = 45 (double strokes)

V = ______metre/min

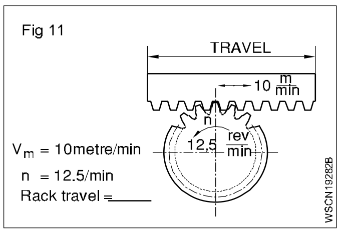
11 

Is : Vm = 25 : 1

n =_____(double strokes)

Is = rack travel

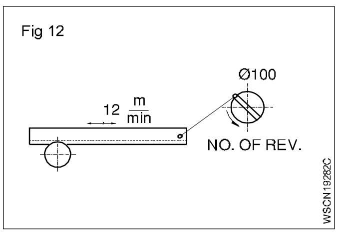
Vxm = stroke speed/ min

12 

Vm = 10 metre/min.

n = 12.5 / min.

Rack travel = ______

13 

dia of crank = 100 mm

Rack

speed = 12 metre/min

Crank disc 'n'' = _____ rpm

14

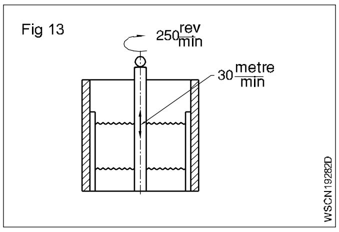


Fig 13

spindle 'n' = 250 rpm

Average stroke speed = 30 metre/min

stroke length = ________mm

15

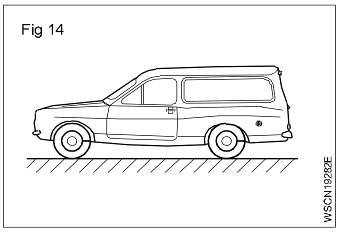


Fig 14

Car Speed = 90 km/hr

Time to stop = 10 sec

Deceleration = ________ metre/ sec^2

16

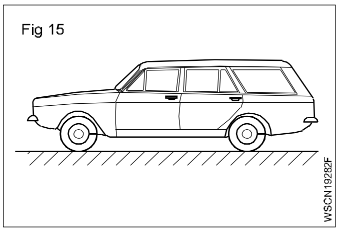


Fig 15

Car speed = 80 km/hr

Distance stopped = 60 metre

Deceleration of car = ________metre/sec^2

17

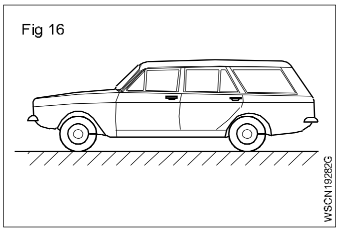


Fig 16

Deceleration = 4.5 m/sec^2

Stopping distance = 50 metres

Velocity of car = ________km/hr

18

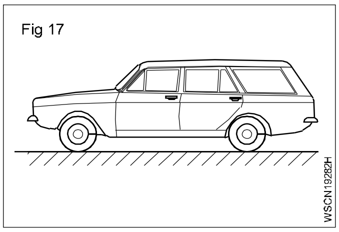


Fig 17

Distance travelled by car = 600 km

Time = 8 hrs 20 min

Average velocity = ________ km/hr

19

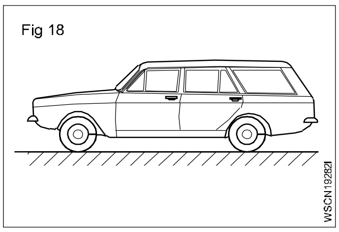


Fig 18

Average velocity = 56.3 km/hr

Distance travelled = 464.475 km

Travelling time = ________ hrs

20

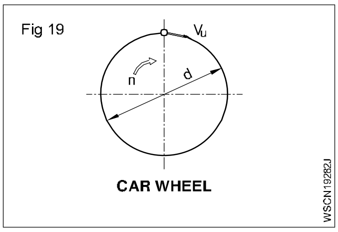


Fig 19

Car wheel

n = 720 rpm

Peripheral speed = 18.84 m/sec

d = ________

21

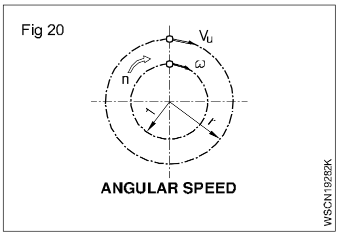


Fig 20

Angular speed

n = 2000 rpm

Angular velocity = _______radians/sec

Use

W = 2πN/60 rad/sec

22

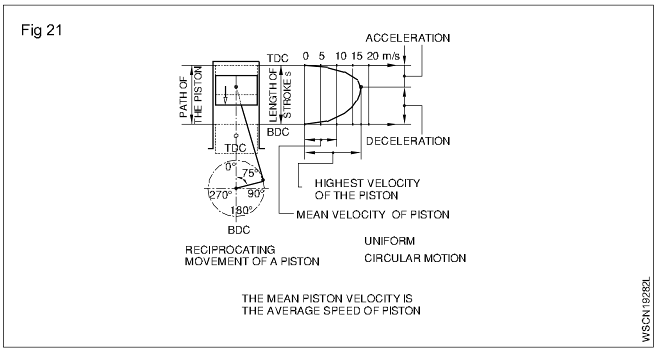


Fig 21

Piston Velocity/Speed

S = 74 mm

n = 4500 rpm

Mean velocity = _______ m/sec

Maximum velocity = _______ m/sec

(Average Speed of Piston)

23 Total Stopping Distance $= \frac{V^2}{2a} + \text{velocity} \times \text{reaction time}$

(Use = $V^2/2a$)

V = Vehicle speed = 80 km/hr

Deceleration = 5m/sec^2

Reaction Time of driver = 2 seconds

Total Stopping Distance = _______ meter

Work(Fig 1)

Work is said to be done by a force, when it moves, its point of application through a distance. Applied force 'F' moves a body through a distance's.

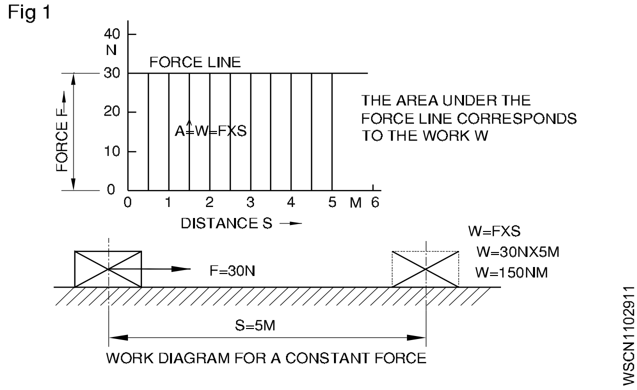
Work done 'W' = F x s.

The S.I. unit of work is 1 joule which is the work done by a force of moving the body through a distance of 1 metre.

Therefore joule = 1 N x 1 metre = 1 Nm

Also 1 joule = 1 Nm = 10^5 dynes x 100 cm = 10^7 dynes cm = 10^7 ergs.

Fig 1



F - force or weight force in N

s - distance the body on which force acts is moved in metres

t - time in seconds

v - speed in metre/sec

w - work done by the force in joules

P - Power in Watts

P_{out} - Power output

P_{in} - Power input

Force

A Force is that which changes or tends to change the state of rest or motion of a body.

Force = Mass x Acceleration

F = Ma

Unit

F = M x a

= kg x m/sec^2

= 1 Newton (SI unit)

(Newton: If 1 kg of mass accelerates at the rate of 1m/sec^2 then the force exerted on the mass is 1 newton)

FPS = 1 pound x 1 Feet/$second^2$

= 1 pound

CGS = 1 gm x 1cm/$second^2$

= Dyne

MKS = 1 kg x 1m/$second^2$

= Newton.

1 Newton = 10^5 dynes

1kg wt = 9.81N

1 pound = 4.448N,

Newton = 0.225 pound.

Absolute units

In C.G.S. system unit of work = 1 erg = 1 dyne x 1 cm

In F.P.S system unit of work = 1 Foot poundal = 1 poundal x 1 foot

In M.K.S. system unit of work = 1 joule = 1 Newton x 1 metre

Derived units

C.G.S. system 1 Gm Wt x 1 cm = 981 ergs.

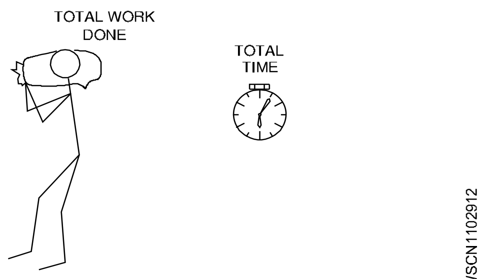
F.P.S. system 1 ft LB = 981 foot poundal

M.K.S. system 1 kgf metre = 981 joule.

Power(Fig 2)

It is the work done in unit time.

Fig 2



$$\text{Power } P = \frac{\text{total work done}}{\text{total time}}$$

$$P = \frac{Nm}{sec}$$

$$\text{The S.I units of power} = 1Nm/sec = \frac{1 \text{ joule}}{sec}$$

$$\text{which is} = 1 \text{ watt. power in watts} = \frac{w}{t} = \frac{F.s}{t} = FXV$$

which is equal to 1 Watt. Power in watts = w/t = F.s/t = F x V

In M.K.S. system the unit is 1 kgf meter/sec. One horse power is = 75 kg metre/sec or 4500 kgf metre/min.

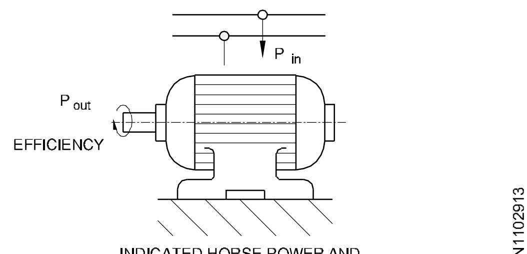
1HP (metric) = 735.5 Watts

1HP (British) = 746 Watts = 0.746 KW

1 KW = 1.34 HP

Power input is the power given to a machine to do work. Power output is what we get out of the machine. Power output is always less than power input due to friction in the machine. The ratio between power output to power input is efficiency of the machine and it is expressed in percentage.(Fig 3)

Fig 3



INDICATED HORSE POWER AND BRAKE HORSE POWER

$$\text{efficiency} = \frac{\text{power output}}{\text{power input}} \times 100\%$$

Indicated Horse Power and Brake Horse Power

The power actually generated by the engine or generator is the indicated horse power which is indicated on the plate.

The Brake horse power is the power available to do useful work. B.H.P is always less than I.H.P. due to losses to overcome frictional resistance.

$$\therefore \text{mechanical efficiency} = \frac{\text{B.H.P}}{\text{I.H.P}} \times 100\%$$

Work done by a force = Magnitude of the force x distance moved by the body

Power = Total work done / total time taken

$$\text{efficiency} = \frac{\text{power output}}{\text{power input}} \times 100\%$$

Energy

The energy of a body is its capacity to do work. It is equal to power x time. Hence the unit of energy is the same as the unit of work in all systems.

Forms of energy

Mechanical energy, Electrical energy, Atomic energy, Heat energy, Light energy, Chemical energy, sound energy. Energy of one form can be transformed into energy of another form.

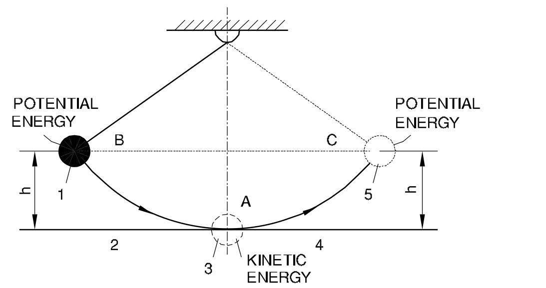
Law of conservation of energy

– The energy can neither be created nor destroyed.

– Total energy possessed by a body remains the same.(Fig 4)

Depending upon the position of the body or body in motion, mechanical energy possessed by the body may be potential energy or kinetic energy respectively.

Fig 4

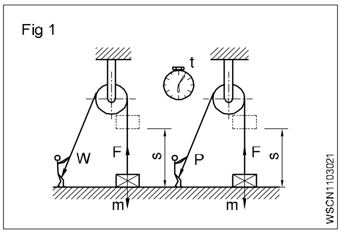


CONSERVATION OF ENERGY

1.STATE OF REST
2.ACCELERATED DOWNWARD MOMENT IN AN ARC
3.STATE OF MAXIMUM VELOCITY
4.RETARDED UPWARD MOVEMENT IN AN ARC
5.STATE OR REST

Assignment

1



m= 55 kg

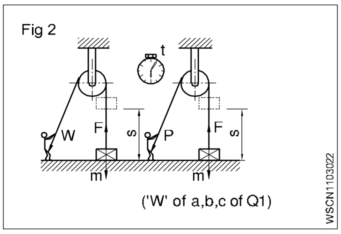
a) s = 1.82 metres
W = ______ joules

b) s = 1.40 metres
W= ____ joules

c) s = 0.85 metres

W =Joules

2



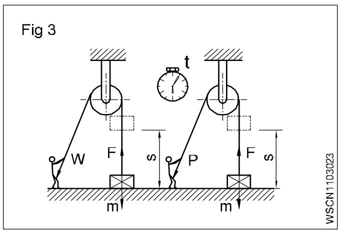
t = 8 secs

a) P = _____ Watts

b) P = _____ Watts

c) P = _____ Watts

3

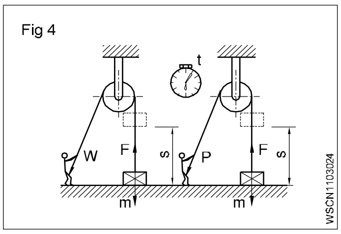


W = 1312.5 Joules

m = 350 kg

s = _____ metres

4



m = 75 kg

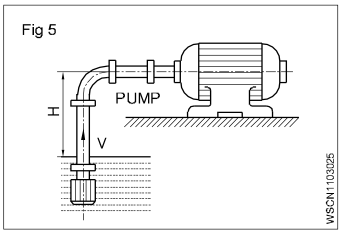
s = 100 metres

t = 12 secs

W = ______ Nm

P = ______ Watts

5



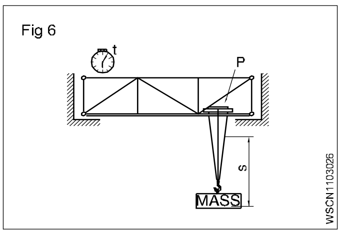
V = 1 m^3/min

H = 2 m

η = 0.75

Power input = ______ kW

6



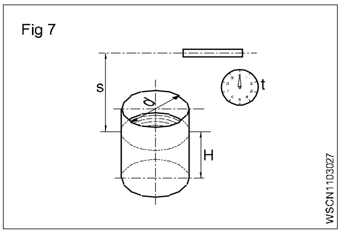
P = 12 kw

s = 4 metres

t = 20 secs

m = ______ kg

7



d = 3 metre

H = 2 metre

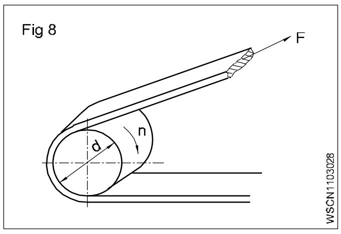
t = 20 minutes

s = 6 metres

P = ______ kW

Water filled in the tank. s is the pumping height

8



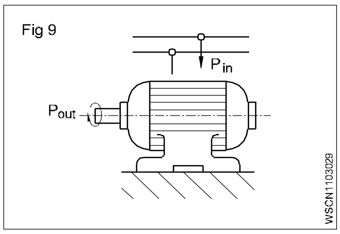
d = 200 mm

n = 750 rpm

F = 700 N

P = _____ kW

9



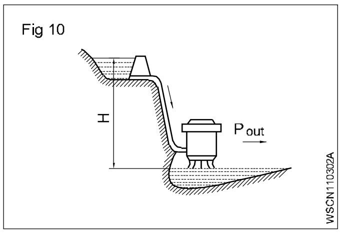
P input = 4 kW

P output

= 3450 Joules/sec

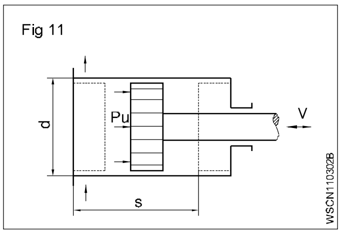
η = ______ %

10



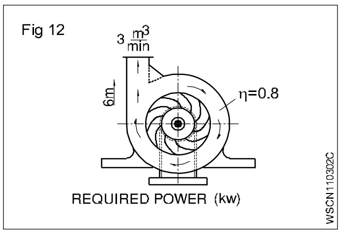
Volume of water
'V' = 10 $metre^3$
H = 18 metres
t = 20 sec
η = 70 %
P output
= ______ kW

11



d = 225 mm
s = 450 mm
Piston pressure
'P' = 4.5 bar
V = 2.5 metre/sec
(piston speed)
η = 70 %
Power input
= _____ kW

12



'V' of water pumped
= 3 metre3/min
H = 6 metre
η = 0.8
Power input
= ______ kW

Potential energy, kinetic energy and related problems with assignment
Exercise 1.5.25

Potential energy

Potential energy is the energy possessed by a body by virtue of its position (Fig 4). A body of mass 'm' kept at a height 'h' from a datum possesses a potential energy of mgh or Wh or Fh; where W or F are the Weight force. When the body is allowed to fall it will be able to do a useful work of Fh.

Example

- Water stored in a Tank
- Coil Spring.

Kinetic energy

It is the energy possessed by a body by virtue of its motion. If a body of mass 'm' starting from rest attains a velocity of 'v' after covering a distance of 's', by the action of an applied force 'F', then work done on the body=F x s But F= m x a. Therefore work done on the body = m x a x s.

But a x s = $\frac{V^2}{2}$ because the body is starting from rest.

Therefore Work done on the body = $\frac{1}{2}mv^2$.

Since work done on the body = The energy possessed by the body

Kinetic Energy = $\frac{1}{2}mv^2$.

Energy possessed by a body = work done on the body

Potential energy = mgh

Kinetic energy = $\frac{1}{2}mv^2$

If friction is neglected potential energy = Kinetic energy

Example

- Rolling vehicle
- Rotating fly wheel
- Flowing water
- Falling weight

Potential energy

Hammer head drops from height 'h' . m = 10 kg.

h = 1.4 m.

$u = 0\frac{\text{metre}}{\text{sec}}$

$V^2 = 2\text{ gs}$

$V^2 = 2 \times 9.81 \times 1.4$

$V^2 = 27.468$

$V^2 = 5.24\text{ m/sec}$

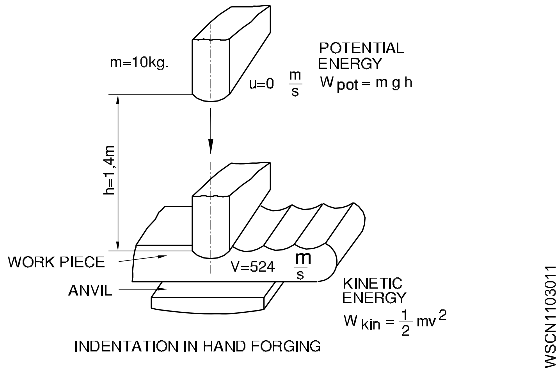
P.E = 10 kg x 9.81 metre/sec^2 x 1.4 metre (Fig 1)

= 137.3 N metre (∵ 1N = 1kg.m/sec^2)

K.E = x 10 kg x 5.24^2 $\frac{\text{metre}^2}{\text{sec}^2}$

= 137.3 N metre.

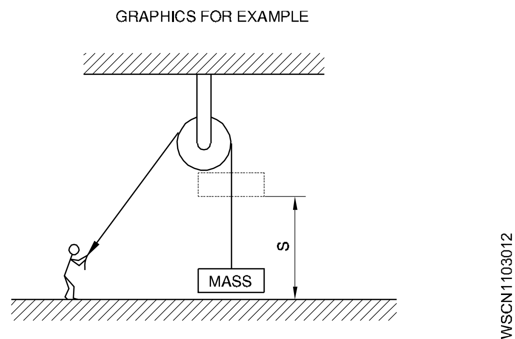
Fig 1



Examples

- A pulley is used to lift a mass with a force of 900 N to a height of 10 metres in 2 minutes. Find the work done by the force and also the power.(Fig 2)

Fig 2



Work done = F x s = 900N x 10 metre

= 9000 Nm = 9000 joules.

Power $= \frac{W}{t} = \frac{9000\text{ joules}}{120\text{sec}}$

$= \frac{75\text{ joules}}{\text{sec}}$

$= 75$ watts

- Determine the horse power required to drive a lift in raising a load of 2000 kgf at a speed of 2 metre/sec, if the efficiency is 70%.

Useful workdone to raise the lift in 1 sec
Force = 2000 kgf
Work = F x d

$$Power = \frac{F \times d}{t} = \frac{2000 \times 2}{1}$$
$= 4000$ w

Power output = 4000 w

Power input = Power output

$$= \frac{4000}{0.7} = 5714 \text{ w}$$

$$\eta = \frac{Output}{Input} \times 100\%$$

$$HP = \frac{5714}{746} = 7.659 \cong 7.6 HP$$

Power input = 7.6 HP

- A mass of 100 gm is allowed to fall from a height of 10 metres. Determine the amount of Kinetic energy gained by the body. (Take the value of g as 10 metre/ sec^2

  Since initial velocity is 0 and distance travelled is 10 metres. final $velocity^2$

  $= V^2 = 2 \times g \times s = 2 \times 10 \times 10$ $metre^2/sec^2$

  $$\therefore K.E = \frac{1}{2}mv^2 = \frac{1}{2} \times 100 \text{ gm} \times 200 \text{ metres}^2/\text{sec}^2$$

  $= 10000 \text{ gm metre}^2/\text{sec}^2$

  $= 10 \times 10^7$ ergs

  $=$ 10 Joules.

K.E. developed by the vehicle at a constant speed

- A motor vehicle of one tonne is travelling at 60 km/hr. Calculate K.E of the vehicle at this speed.

  K.E of the vehicle = $\frac{1}{2}$ mv^2

  Where m = one tonne or 1000 kg

  v = 60 km/hr

  Solution

  Changing v into meter/sec we get,

  $$V = 60 \times \frac{1000}{60 \times 60} = \frac{50}{3} \text{ m/sec}$$ ($\because$ 1km = 1000m)

  ($\because$ 1hour = 3600sec)

$$\text{Now K.E. of vehicle} = \frac{1}{2} \times 1000 \times \frac{50}{3} \times \frac{50}{3}$$

$$= 1000 \times \frac{2500}{18}$$

$$= \frac{2500000}{18} J$$

$$= \frac{2500000}{100 \times 18} KJ$$

$$= \frac{1250}{9} KJ$$

$= 138.89$ KJ

K.E.developed by a vehicle during acceleration

- A motor vehicle of 1200 Kg mass is being accelerated from 36 km to 48 km/hr speed. Calculate the increase in K.E during its acceleration.

  Solution

  Mass of motor vehicle= 1200 kg

  K.E. of the vehicle at 36 km/hr speed

  $= \frac{1}{2}$ x 1200 x 36^2J KE= $\frac{1}{2}$ mv^2 J

  v= 36km/hr $= 36 \times \frac{1000}{60 \times 60} = 10$m/sec

  K.E of the vehicle at 48 km/hr speed

  $= \frac{1}{2}$ x 1200 x 48^2J ($\because$ 1kg.m/sec^2 = 1N)

  ($\because$ 1Nm = 1J)

  v= 48 km/hr $= 48 \times = \frac{1000}{60 \times 60} = \frac{40}{3}$ m/sec

  KE = $\frac{1}{2}$ x1200 x 10 x10=60000J

  KE = $\frac{1}{2}$ x1200 x $\frac{40}{3}$ x $\frac{40}{3}$ =106666.67 J

  Increase in K.E of the vehicle = 106666.67 J - 60000J
  = 46666.67 J
  = 46.666 KJ.

Workdone in vehicle operation

The Mechanical Work performed by the motor vehicle for its propulsion on road can generally be classified into two major categories of work done.

- Workdone by the IC engine in developing full power under all condition of speed and load.
- Workdone by the motor vehicle in performing different operations on road like hill climbing/acceleration/braking/ towing and reversing operation