UNIT 4

WORK & FRICTION

WORK

Work is said to be done If a force is applied on a body, & displaces the body through a certain displacement such that it has a nonzero component along the direction of force .

Mathematically W = $\vec{F}.\vec{S}$

W = FS Cos θ

Where θ is the angle bet $\vec{F}$ & $\vec{S}$.

If θ = 0° then Cos 0° = 1 hence W = FS Maximum

If θ =90° then Cos90° =0 hence W = FS X 0= 0.

If θ = 180° then Cos 180° = -1 hence W = -FS = Minimum

Dimensional formula of work is $[M^1L^2T^{-2}]$

In SI System If F =1 N, S=I met then W = 1N X 1 met = 1 joule

In CGS system If F = 1 dyne, S = 1cm then W = 1 dyne x 1 cm = 1 erg

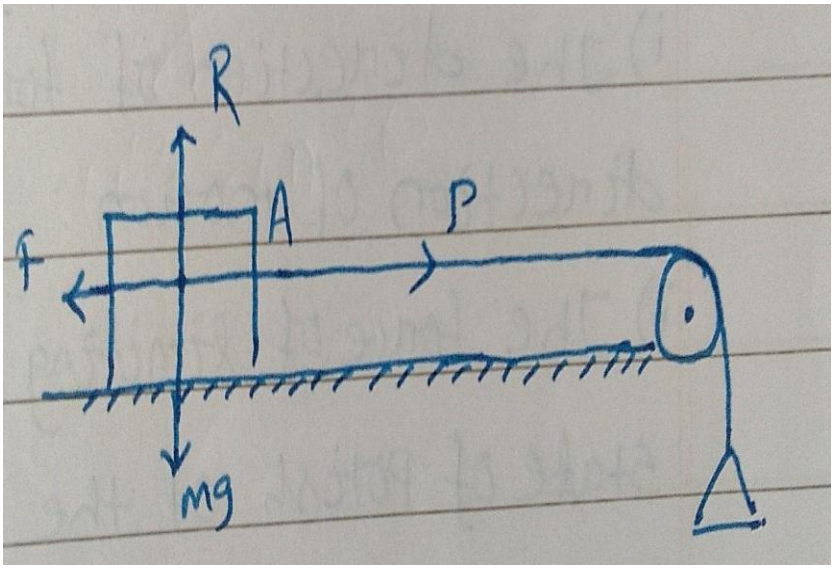
1 joule = 10^7 erg

FRICTION -DEFINITION OF STATIC, LIMITING & DYNAMIC FRICTION

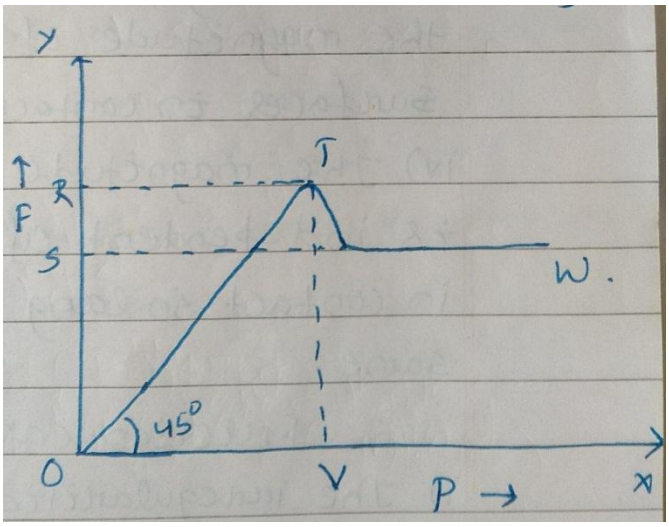
The force of friction which comes into play between two surfaces when one tends to slide over the other is called sliding friction.

Consider a block A of mass m placed over a surface. A string is tied to a block & passes over a Pulley and has a scale Pan Suspended from its other end. When some weight Put in the Pan the string Pulls the block in forward direction & and is opposed by the force of friction F acting in backward direction. Weight & the normal are in vertical direction so they don't contribute to the sliding tendency.

With slight increase in P, the body doesn't slide. It means F increases along with p automatically Hence friction is a self adjusting force.



A graph is plotted between P & F . The graph is straight line 0T Passing through the origin inclined to x-axis at an angle 45° value of force of friction corresponding to any Point on OT is called static friction.



STATIC FRICTION is the force of friction between two surfaces so long as there is no relative motion between them. It will observed that the value of the static

friction increases up to T beyond which if the applied force is increased body starts moving. This maximum value of force of friction is called limiting friction.

LIMITING FRICTION is the maximum value of force of friction between two surfaces so long as there is no relative motion between them.

Now on increasing P beyond OV, the body start sliding. It is seen that force of friction decreases a little from OR to OS and then remains constant throughout. Further increase in P will produce an acceleration in the body. This force of friction is called dynamic friction.

DYNAMIC FRICTION is the force of friction which comes in to play between two surfaces when there is some relative motion between them.

LAWS OF LIMITING FRICTION

The laws of limiting friction are as follows.

i) The direction of force of friction always opposite to the direction of motion.

ii) The force of limiting friction depends upon the nature and State of Polish of the surfaces in contact and acts tangentially to the interface between the two surfaces.

iii) The magnitude of limiting friction F varies directly to the magnitude of normal reaction R between the two Surfaces in contact.

Mathematically $F \propto R$

(iv) The magnitude of limiting friction between two surfaces is independent of the area and shape of the surfaces in contact so long as the normal reaction remains the same.

METHODS TO REDUCE FRICTION

Friction can be reduced by following methods.

1) The irregularities of the surface are smoothened by rubbing to avoid interlocking. It reduces the friction.

2) When a lubricant (oil on grease) is spread over the surface, fills the irregularities and avoids interlocking. So friction is reduced.

3) if we convent sliding friction into rolling friction then friction can be minimised.

4) If a body can be streamlined by shape then fluid friction can be minimised. It is the only cause of Pin-Pointed Shapes of aeroplanes, rockets etc.

Co-efficient of friction of a pair of surfaces in contact is defined as the ratio between the force of limiting friction F to the normal reaction R. It is denoted by μ.

Mathematically $\mu = \frac{F}{R}$

Two Mark Questions

1 Define work & write its units .

2 Write the dimensional formula of work .

3 Wrtie the condition of work to be maximum and minimum .

4 Define static dynamic and limiting friction .

5 Write any two methods to reduce friction .

6 Define co efficient of friction and write its working formula .

Five Mark Questions

1 State laws of limiting friction .

2 Explain the types of friction with neat diagram and graph .

3 Write any five methods to reduce friction .

UNIT 5

GRAVITATION

NEWTON'S LAW GRAVITATION

It states that every material body in the universe attracts every other material body towards itself with a force which varies

i) Directly as the product of their masses.

ii) inversely as the square of the distance between their centre.

Let A & B be two material bodies

M,m →Masses of body A & B

r → distance between their centre

F →force of attraction bet A & B

According to law $F = Mm/r^2$

$F = GMm / r^2$

Newton's Law of Gravitation where G is called universal gravitational constant

G= 6.67 x 10 N m^2/Kg^2. since G is Small, gravitational force is very small.

Universal gravitational constant is defined as the force exprienced between two bodies having unit mass separated by a unit distance.

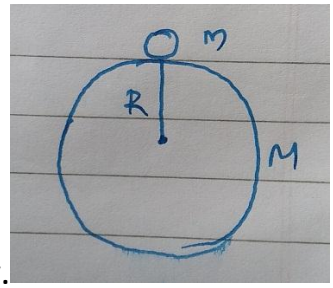
Its dimensional formula is $[M^{-1}L^3T^{-2}]$

ACCELERATION DUE TO GRAVITY, VARIATION OF ACCELERATION DUE TO GRAVITY WITH HEIGHT & DEPTH

Consider a body on the surface of earth.

Let M, m→ Masses of earth & body respectively.

R → radius of earth



g →acceleration due to gravity.

F →gravitational force

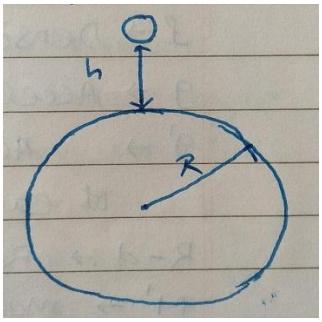
W= mg →weight of the body

Now $mg = GMm/R^2$

or $g = GM/R^2$

since g depends upon mass of planet and radius of planet ,It is not a universal constant.

Variation with height



consider a body is taken to a height above the surface of earth.

Let M , m → Masses of earth & body respectively.

R →radius of earth

h → distance of the body from surface of earth.

g → acceleration due to gravity at the surface of earth.

g' →acceleration due to gravity at a height h from surface of earth

Now $g = GM / R^2$

& $g' = GM/(R+ h)^2$

Dividing g' by g we get $\frac{g'}{g} = \frac{GM}{(R+h)^2} \times \frac{R^2}{GM} = \frac{R^2}{(R+h)^2}$

$\frac{g'}{g} = \frac{R^2}{R^2(1+\frac{h}{R})^2}$ or $\frac{g}{g'} = (1+\frac{h}{R})^{-2}$

h <<R & h/R is very small. Expanding the R·H·S of above equation by Binomial Theorem and neglecting higher powers of h/R we get

g'/g =1 - 2h/R

g' = g - 2hg/R

or g - g' = 2hg/R

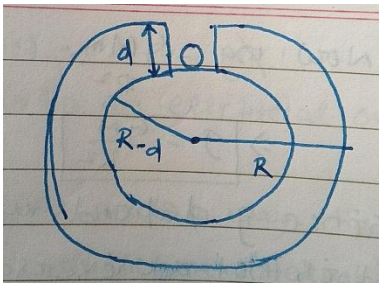
The RHS of above equation to +ve so g > g'

or (g - g') α h

The value of acceleration due to gravity decreases with increase in height above the surface of earth.

Variation with depth

Consider a body is taken to a depth below the free surface of earth as shown in figure. Assume earth to be homogeneous .



Let M→ mass of earth

R →radius of earth

d → distance of the body at depth from surface of earth.

ρ → density of earth.

g → acceleration due to gravity at the surface

g' → acceleration due to gravity at the depth d from surface of earth

R-d → radius of inner solid sphere.

M' → mass of inner solid sphere of Radius (R-d)

Now g= GM/R² & g' = GM' / (R-d)^2

g = $\frac{GR^3\pi\rho\frac{4}{3}}{R^2}$ and g' = $\frac{G\frac{4}{3}\pi\rho(R-d)^3}{(R-d)^2}$

or $\frac{g'}{g}$ = 1 - $\frac{d}{R}$

or g – g' = dg/R

The RHS of above equation is +ve so g >g'

or (g -g') α d

The value of acceleration due to gravity decreased with increase in depth.

Special cases

If d=R.

g - g' = Rg /R

or g' = g - g = 0

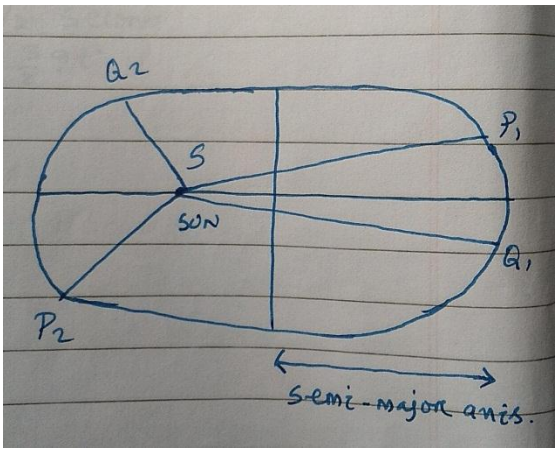
It means acceleration due to gravity is zero of the centre of earth.

KEPLER'S LAWS OF PLANETARY MOTION

1st law → A Planet moves round the sun in an elliptical orbit with Sun situated at one of its foci.

2nd law →A Planet moves round the sun in such a way that its areal velocity (equal area swept in equal time interval) is constant.

Let t → time taken by Planet to go from P_2 to Q_2 so that line SP_2 covers an area P_2SQ_2



While going from P_1 to Q, Planet moves in such a way that

Area P_2SQ_2 = Area P_1SQ,. Since $SP_1 > SP_2$

$P_1Q_1 < P_2Q_2$

P_1Q_1 & P_2Q_2 are the distances travelled along the orbit in same time. It concludes that the orbital velocity of a planet is not uniform.

3rd law → A Planet moves round the sun in such a way that the square of time period of revolution varies directly to the cube of semi major axis of its elliptical orbit.

$T^2 \alpha a^3$

where T→ Time period of revolution

a → semi major axis.

MASS AND WEIGHT

Mass

1. The amount of matter contained in a body is called mass.

2. It is a scalar quantity.

3. Its SI unit is kg.

4. It is a constant quantity.

5. It is never zero for a material body.

6. It is an essential property of material bodies.

Weight

1. It is the force with which a body is attracted towards the centre of earth.

2. It is a vector quantity.

3. Its SI unit is newton.

4. It may vary from place to place since it depends upon the value of 'g' at a place.

5. It is zero at the centre of earth. It may also be zero in some special circumstances.

6. It is not an essential property of material bodies.

Two Mark Questions

1 Difference between mass and weight .

2 Write the dimensional formula of G and its SI unit.

3 What happens to acceleration due to gravity with increase in height and increase in depth ?

4 Write the value of G.

5 Write the value of g at the centre of earth and at which place it is maximum ?

6 Define Kepler's 3rd law of planetary motion. .

Five Mark Questions

1 State and explain Newton's law of gravitation .

2 State and explain Kepler's laws of planetary motion .

3 Write any five difference between mass and weight.

UNIT 6

OSCILLATIONS AND WAVES

SIMPLE HARMONIC MOTION

The motion of a body is said to be periodic if it passes through similar conditions after equal intervals of time.

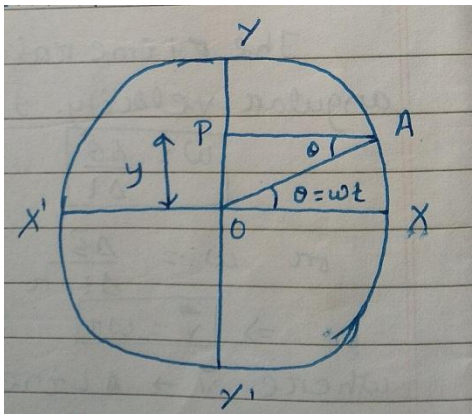
A particle is said to move in SHM If its acceleration is proportional to the displacement and is always directed towards the mean position.

Ex swing in the park , oscillating pendulum ,motion of a spring etc.

EXPRESSION FOR DISPLACEMENT VELOCITY AND ACCELERATION OF A PARTICLE EXECUTING SHM

Consider a particle A undergoing Uniform Circular motion in a circle XYX'Y' . P is the projection of the particle. While A is moving from X to Y to X' to Y' to X, P moves from O to Y to O to Y' to O. When particle performs uniform circular

motion, its projection keeps on vibrating to and fro motion about O . So there is a relation between them.



Let r→ Radius of the circle.

w →angular velocity

t → time taken by particle to move from X to A

θ = wt → angular displacement.

y = OP→ An instantaneous displacement.

From right angle triangle OAP sin θ = OP/OA => sin θ = y/r

or y = r sinθ equation 1

Displacement of the particle executing SHM

Now differentiating equation 1 with respect to time we get

$\frac{dy}{dt}$ = v = $\frac{d}{dt}$ (r sinwt)

or v = r w cos wt equation 2

velocity of the particle executing SHM.

Now differentiating equation 2 with respect to time we get

$\frac{dv}{dt}$ = a = $\frac{d}{dt}$ (rw cos wt)

=> a = - rw^2 sinwt equation 3

Acceleration of the Particle executing SHM...

or a = -w^2y or a α -y

The acceleration produced varies directly to the displacement. -ve sign indicates that acceleration is directed towards the mean position.

WAVE MOTION

It is disturbance that travels through the medium and is due to repeated periodic motion of the particles of the medium the motion being handed over from particle to particle.

Transverse Wave

1) It is defined as the wave motion in which the particles of the medium are vibrating in a direction at right angles to the direction of propagation of wave.

2) it travels in the form of crest and trough .

3) Light waves are transverse in nature.

4) It acts on two dimension .

5) The wave can be Polarized or aligned.

Longitudinal wave

1) It is defined as the wave motion in which the particles of the medium vibrating in a direction parallel to the direction of propagation of wave.

2) it travels in the form of compression & rare faction.

3) Sound waves are longitudinal in nature.

4) It acts in one dimension.

5) The wave can't be Polarized or aligned.

DIFFERENT WAVE PARAMETERS

Wave length :- It is defined as the distance travelled by a wave during the time when particle completes one

vibration (λ) OR It is the distance between two consecutive crests and troughs.

Amplitude :- It is defined as the maximum displacement of the particle.

Frequency :- It is the no. of vibration made by the body in one second (n)

Time period :- It is the time taken by the particle to complete one vibration (T)

Wave velocity :- It is the distance travelled by the wave during time a Particle completes one vibration. (V)

$V = \lambda / T$

or $V = \lambda \times n$

wave velocity = wave length x frequency.

ULTRASONICS – DEFINITION , PROPERTIES & APPLICATIONS

Sound wave is audible to human ear if the frequency of wave is 20 Hz to 20,000 Hz. This range is called audible range. The frequency of waves above audible range is called Ultrasonic waves. It has range from 20,000 Hz to 10^9 Hz

Application:

1) It is used to measure the thickness of rolled metal sheets.

2) The depth of deep sea is measured by using ultrasonic

3) It is used as catalyst in chemical effects.

4) It is used in medical science to detect various diseases.

5) It is used to destroy some bacteria.

6) It is used for drilling holes in hard and brittle materials.

7) It is used to welding two surfaces.

Properties

1) Ultrasonic are longitudinal in nature .

2) As the ultrasonic are longitudinal, it creates a compression & rare faction through a medium.

3) The range of ultrasonic is 20,000 Hz to 10^9 Hz

4) Ultrasonic travel with the speed of sound.

5) Ultrasonic are highly energetic waves.

6) Ultrasonic have smaller wave length & constitute narrow beams.

7) Some liquid can be used as diffraction grating to produce diffraction of light by passing ultrasonic through it.

Two Mark Questions

1 Define simple harmonic motion .

2 Write any two difference between transverse and longitudinal wave.

3 Define wave length .

4 Define wave velocity

5 Define ultrasonic .

6 Write any two properties of ultrasonic .

7 Write any two uses of ultrasonic .

8 Define Wave motion .

Five Mark Questions

1 Write any five difference between transverse and longitudinal wave.

2 Define ultrasonic . Write its properties and uses .

3 Write any five difference between mass and weight.

Ten Mark Questions

1 Define simple harmonic motion. Derive the expression for displacement velocity and acceleration of a particle executing SHM .