`F = (GMm)/r^2`

`G = 6.67 \* 10^(-11)`

Gravitational force is independent of medium

Two or more gravitational forces at a body do vector addition

Acceleration due to gravity

`G = F/m = (GM)/R^2 = 9.8`

`g propto 1/R^2 ` g is minimum at equator and maximum at poles

Height h above the surface of earth

`g’ = g/((1 + h/R)^2)`

Binomial approximation `g’ = g(1 – (2h)/R)`

Depth below the surface of earth

` g’ = g(1 – d/R)`

Change in g due to axial rotation of earth

`g’ = g – romega^2cos^2phi`

This is the effective value of g, it directed to the center of earth and not passing vertically

This reduction in the value of g is due to centrifugal force due to rotation

Gravitational field strength or intensity of gravitational field: it is the space around a body where a test mass experience gravitational force

`E = F/m = (GM)/r^2`

Gravitational field due to a uniform solid sphere

Field at an external point

E = (GM)/r^2 for r > R

Field at an internal point

E = (GM)/R^3 r for r < R

Field due to a uniform spherical shell

E = (GM)/r^2 r> R

At an internal point

E = 0 field inside is zero

Field due to a uniform circular ring at some point P on its axis

&image&

P

`E = (GMr)/((R^2 + r^2)^(3/2))`

It is zero at the center and max at `r = R/sqrt(2)`

`E\_{max} = (2GM) / (3sqrt(3) R^2)`

Gravitational potential : at any point is the negative of work done by gravitational force in moving a unit test mass from infinity (where potential is zero) to that point .

Thus potential at P

`V\_{p} = (-W\_{infity rightarrow P})/m`

Potential due to point mass

F = (-Gm)/r

r = distance from point mass to the point

potential due to uniform solid sphere

external point:

V = (-Gm)/r r>R

Internal point

V = (-Gm)/R^3(1.5R^2 – 0.5r^2) r<R

The potential of spgere at center is 1.5 times potential at trhe surface

Potential due to uniform thinspherical shell

External point

V = (-Gm)/r r>R

Internal point

V = (-Gm)/r

It is constant at any point inside the shell

Potential due to uniform ring

V = (-Gm)/ (sqrt(R^2 + r^2))

Relation between E and V

`E = (-dV)/(dx)`

E = - slope of V – x graph

Vector case

`E = -[(dV)/(dx) hati + (dV)/(dy) hatj +(dV)/(dz) hatk]`

Gravitational potential energy

`U = -int\_infty^r F\*dr = -W`

Gravitational potential energy of a two particle system

`U = (-Gm\_{1}m\_{2})/r `

r is the distance between them

Gravityational potential energy for system of particles (`m\_{1}, m\_{2}, m\_{3}, m\_{4}`)

`U = -G [(m\_{4}m\_{3})/r\_{43} + (m\_{4}m\_{2})/r\_{42} + (m\_{4}m\_{1})/r\_{41} + (m\_{3}m\_{2})/r\_{32}+ (m\_{3}m\_{1})/r\_{31} + (m\_{2}m\_{1})/r\_{21}]`

Grvitional potential energy of a body on earths surface

`U = (-GMm)/R`

As the object moves to height h above earth

`DeltaU = (mgh)/(1+h/R)`

h << R `DeltaU = mgh`

maximum height obtained by a particle projected with a velocity v vertically up

decrease in K.E = increase in P.E

`1/2mv^2 = DeltaU`

`h= v^2/ (2g – v^2/R)`

Binding energy

It’s the energy due to which different parts of system are bound to each other

abs(E) =abs( K + U) = 0 + (GMm)/r

abs(E) = (GMm)/r

It is the mimum energy for a particle leave the surface of earth

Escape velocity

V\_{e} = sqrt(2gR) g = (GM)/R^2

`V\_{e}` of earth = 11.2 km/s

Orbital speed

V\_{0} = sqrt((GM)/r)

For earth v\_{0} = 7.9km/s

Period of revolution

`T = 2pisqrt(r^3/(gR^2))`

T propto r^(3/2) --- keplers law

T of satellite close to earth = 84.6 min

Energy of satellite

U = (-GMm)/r

K.E = 1/2(GMm)/r

Total energy = (-GMm)/(2r)

Mimum E required to launch a satellite is

E = energy of satellite – energy of mass on the surface of earth

= (-GMm)/(2r) - (-GMm)/r

To escape from the orbit (gravitational pull) `v\_{e} – v\_{0}` is the additional velocity needed

Keplers laws

1. Law of elliptical orbits: each planet moves in a in elliptivcal orbit, with sun at one of its focus
2. (dA)/(dt) = L/(2m)

(dA)/(dt) = areal velocity(area swept per unit time )

1. T propto r^(3/2)

`(dL)/(dt) = r xx F = tau`

`(dL)/(dt)` , then L =constant

Hence keplers second law is law of conservation of angular momentum

Body on moons surface accel;eration by moons gravity is

`g’ = g\_{e}/6`

Acceleration of that body by earthsgravity is

`g’ = g\_{e} /(60)`