Moment of inertia(MI) = mass x perpendicular distance from axis

MI depends on mass, shape and size of body and axis of rotation

MI of ring perpendicular = MR^2

MI along diameter of ring = (MR^2)/2

MI of axis perpendicular to disc = (MR^2)/2

MI along diameter of disc = (MR^2)/4

MI about axis along center of solid cylinder = (MR^2)/2

MI about axis perpendicular to center of solid cylinder = (MR^2)/4 + (ML^2)/(12)

MI about axis along center of hollow cylinder = MR^2

MI about axis perpendicular to thin rectangular plate(same for cuboid) = M/(12) (a^2 + b^2)

MI about axis perpendicular to square plate = (Ma^2)/6

MI about diagonal axis of square plate = (Ma^2)/(12)

MI about axis perpendicular to thin rod = (ML^2)/12

MI of axis perpendicular to one end of rod = (ML^2)/3

MI of uniform rod about an axis passing through one end making angle`alpha` with axis of rotation

&image&

rꞱ

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L

α

I = (ML^2(sin)^2alpha)/3

MI of solid sphere = 2/2MR^2

MI of hollow sphere = 2/3MR^2

Torque is the roitational analog of force

`Tau = vec r\_{bot} xx vec F = rFsintheta` = `|[hat i, hat j, hat k], [r\_{1}, r\_{2}, r\_{3}], [F\_{1}, F\_{2}, F\_{3}]|`

Torque about a point or axis, take perpendicular distance to that point or axis and take cross product with force

Direction can be obtained by right thumb rule

Right thumb rule

Keep four fingers in direction of r , which is from axis to force, then rotate the four fingers towards direction of force so the thumb shows direction of the resultant vector `tau`

Translational eqbm F\_{net} = 0

Rotational equilibrium `tau\_{net} = 0`

For rigid boddy to be in equilibrium it needs to satisfy both rotational and translational equilibrium

`F\_{net} = 0` and `tau\_{net} = 0`

Analogy

Translational rotational

Linear displacement (s) angular displacement (`theta`)

Linear velocity(v) sangular velocity(`omega`)

`v =(ds)/(dt) v =r`omega` `omega(dtheta)/(dt)`

Linear /tangential acceleration angular acceleration(`alpha`)

A\_{t} = (dv)/(dt) a\_{t} = ralpha alpha = (domega)/(dt)

Mass(inertia factor) moment of inertia

Linear momentum p = mv angular momentum L = Iomega

Newton second law newtons second law

F\_{ext} = (dp)/(dt) =ma tau\_{ext} = (dL)/(dt) = Ialpha

K.E = 1/2mv^2 K.E = 1/2Iomega^2

Linear impulse = FDeltat rotational impulse = tauDeltat

= change in linear momentum = change in angular impulse

Work = F\*s work = tau\*theta

Conservation of linear momentum conservation of angular momentum

F\_{ext} = 0 (dp)/(dt) = 0 tau\_{ext} = 0 (dL)/(dt) = 0

P\_{total} = constant L\_{total} =constant

a=(vdv)/(ds) alpha(omegadomega)/(dtheta)

v =u +at omega = omega\_{0} +alphat

s = ut +1/2at^2 theta = omega\_{0}t + 1/2alphat^2

v^2 –u^2 = 2as omega^2-omega\_{0}^2 = 2alphatheta

s\_{n} = u + a/2(2n-1) theta\_{n} = omega\_{0} + alpha/2(2n -1 )

(distance traveled in nth second)

Linear impulse `xx` distance(bot) = angular impulse =change in angular momentum

Theorms of moment of inertia

Parallel axis theorm

&image&

AN

a

CMMN

BN

Shift of axis from CM to AB

I\_{AB} = I\_{cm} Ma^2

a = perpendicular distance between two

perpendicular axis theorem

&image&

x

y

if all three axis x, y ,z intersect then , to find MI along axis(here we find MI along z axis)

`I\_{z} = I\_{xx’} + I\_{yy’}`

Radius of gyration

I =mk^2

k = radius of gyration m = mass of body I = MI

MI of bodies with cut(for questions)

&image&

R

O

MI of shaded area of disc + MI of cut disc at O(parallel axis) = MI of whole disc

Force couple

&image&

F

d

F

F\_{net} = 0 then, Torque about any point = Fd

tau\_{net} = 0 only when d = 0

point of application of force

Is a point where torque of all forcers is zero

In question: find net torque of a body from a point by adding individual torque of each force, which is equal to product of distance from that point to net force

Concept of point of application of force is imaginary as some cases it can lie outside body

K.E of rigid body

In combined translational and rotational motion is

K.E = 1/2mv\_{com}^2 + 1/2I\_{com}omega^2

Uniform pure rolling

&image&

Rω

v

P

Q

v\_{p} = v\_{q}

v-Romega = 0

v= Romega

v > Romega rightarrow forward slipping

v < Romega rightarrow backward slipping

velocity of a particle in circular motion at any point p is

θ

P

v\_{p} = 2vsintheta/2

the path of point on the circumference moved in one full rotation is 8R

accelerated pure rolling