Welcome student, I'm doctor Miskil Naik

Assistant Professor in Physics,

DCT’s Dhempe College of

Arts & Science, Miramar ,Goa

My topic for discussion is

from moving coordinate system.

In this module I’ll discuss

about laws of motion.

on rotating Earth and Coriolis force.

At the end of this module,

learner will be able to explain law of

motion on the rotating earth and also

explain the effect of Coriolis force/

Laws of motion on rotating earth.

Consider two coordinate systems,

one which is fixed in space and

other one which is on the Earth.

but it is rotating along the earth with

some angular velocity vector omega.

Consider a particle of mass m

on the surface of the earth,

and this particle is being

acted upon gravitational force.

It is also acted by magnetic force.

The equation of motion relative to coordinate

system which is fixed in space for

a particle of mass m and which is

subjected to gravitational force,

mg and non gravitational force vector

F is given by m into d two by dt square of

vector r which is equals to vector F plus mg.

In a coordinate system particle which is

at rest relative to Earth which rotates

with constant angular velocity omega.

Now this particle is moving with

angular velocity vector omega and the

position vector from center be vector r

Let theta be the angle traced by

the particle along with vector omega.

The equation of motion is given

by m into d two by dt square of vector r

which is equal to m into d star square by dt square

of vector r

plus 2 m vector omega

cross d star by dT of vector

r plus m into vector omega

cross vector omega cross vector

vector r plus m into d by dt of

vector omega cross vector r.

Let us look at equation 2.

The second term that is 2 m vector

omega cross, d star d t vector r. This

is a Coriolis acceleration and it

is present only when particle is in

motion with respect to rotating system.

The third term in equation 2,

vector omega, cross vector

omega cross vector r.

This is called the centripetal acceleration

and is directed towards the axis of rotation.

The fourth term d by dt vector omega

cross vector r is angular acceleration of the particle

due to the acceleration of rotating axis.

If d by dt of vector omega is zero,

then the last term will go to zero.

And equation two, will reduce to m into d two by dt square

of vector r is equal to m into

dstar square by dt square of vector r

plus 2 m vector omega cross

d star by dt vector r

plus m into vector omega cross

vector omega cross vector r.

Let us look at equation one and

compare it with equation three.

We find that left hand side of

equation one and equation 3 is same.

So we equate equation one with equation 3.

So vector F plus mg equals to m into d star square

 by d square vector r plus

2 m vector omega cross d star by dt

vector r plus m into vector omega cross vector

omega cross vector r.

Let us rearrange equation 4.

So taking m d star square by

dt square vector r which will be equal

to vector F plus mg

minus m into vector omega cross

vector omega cross vector r

minus 2 m vector omega cross

d star by dt vector r.

Let us look at equation 6 again.

mg is a gravitational force.

and minus m into vector omega

cross vector omega cross vector r,

is the centrifugal force.

Also, let us write g minus vector,

omega, cross vector

omega cross vector r as g(e).function of r

Where g (e) is effective gravitational force.

Minus vector omega cross vector

omega cross vector r, this is the radially

outward force from the axis and this

force is called as centrifugal force.

The experimentally

measured gravitational force,

which is m times g

is not a long mg.

The centrifugal force,

which is minus m times vector omega cross vector

omega cross vector r is zero at

the North Pole and at South Pole,

and it is maximum at the equator.

If the angle that is traced between vector,

omega and vector r

is theta that we can write modulus of vector,

omega cross vector,

omega cross r which is equal to

omega square r sine theta and let

us take the component of g along

horizontal which will be omega

square r sin theta into cos theta

and along vertical which will be g

minus omega square r sin theta into

sin theta which will be equals to

g minus omega square r sine square theta.

Body that is released near surface of Earth

will begin to fall with acceleration g(e).

Its direction is determined by

plumb line and it will come to

equilibrium with its surface,

which is perpendicular to g(e)..

Hence earth has oblate ellipsoid flattened

at the poles so that every point on the

Earth's surface is made perpendicular to g(e).

At the equator, the angle between vector

omega and vector r is 90 degrees.

vector omega cross vector is

perpendicular to the plane that is

formed by vector omega vector r.

So the mode of vector omega,

cross vector omega plus vector r

which is equal to omega square r.

For omega square r very much less than g

the vertical component of

effective gravitational force

will be nearly equal to g.

and in that case we can write

the angle Phi that is between g and g(e).

given as Phi equals to omega square r

sin theta cos theta by g or omega

square r sin 2 theta by 2 g.

The period of earths rotation

motion is 24 hours,

So angular velocity will be

equal to 7.273 into 10 raise to,

minus five radians per second

Equatorial radius of the earth,

which is 6.378 into 10 raise to 6 meters,

So we can write omega square r which is

equal to 0.0337 meter per second square.

Measured value of the acceleration

due to gravity at the equator is

9.78 meters per second square.

So the centrifugal acceleration is

small compared to acceleration due to

gravity at the surface of the earth.

Coriolis force.

The second term in equation 2,

that is 2 m vector omega cross d star

by dt into vector r is called

Coriolis acceleration and it is present

only when the particle is in motion

with respect to rotating system.

Coriolis force depends upon the mass,

It depends upon the velocity of the particle

and the angular velocity of the earth.

Direction of Coriolis force will be

at a right angle to the plane formed

by Vector v and vector omega.In the

Northern hemisphere body release near

the surface of the earth is deflected

eastward due to the action of Coriolis

force and in Southern hemisphere

body released near the surface of

the Earth is released westward due

to the action of Coriolis force.

Cyclones, is an example of Coriolis force.

Coriolis force plays very important

role in the formation of cyclones.

In a cyclone,

the wind whirls in the anticlockwise

direction in northern hemisphere,

whereas it whirls in the clockwise

direction in the southern hemisphere.

Whenever a low pressure area is formed,

then the mass of air rushes to that area,

then the Coriolis force always will act on

this and it will direct it to the right

in the northern hemisphere and

it will direct it to the left in

the southern hemisphere.

These are the books for your further reference.

Thank you.