# APPLIED SCIENCE – 1(PHYSICS)
# OCTOBER 2010

PART –A

(Answer the question in one or two sentences. Each question carries 2 mark)

I. a) Give the physical quantities and their units in which SI is based on.

Ans:

| Quantity | Unit |
|---|---|
| Length | meter |
| Mass | kg |
| Time | S |
| Electric current | ampere |
| Temperature | K |
| Amount of substance | mol |
| Luminous intensity | cd |
| Plane angle | rad |
| Solid angle | sr |

b) State and explain Newton's law of gravitation

Ans: Every body in the universe attracts every other body with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

F = G $\frac{m_1 m_2}{r^2}$

PART – B

(Answer any two questions. Each question carried 8 mark)

II. a)Deduce that a projectile can have two angles of projection for ranges other than the maximum range. (4)

Ans: The horizontal range , R = $\frac{u^2 sin2\theta}{g}$

Since $sin2\theta = sin(180 - 2\theta)$, the range will be the name for angles $\theta$ and 90°-$\theta$. But for the maximum range , sin2$\theta = 1. that\ is, 2\theta = 90° \ and\ \theta = 45°$

Thus , for ranges other than the maximum range, there can be two angles of projection.

b)Analyze the statement – Newton's first law defines force and second law provides a means to measure force. (4)

Ans: Newton's first laws defines force because it states that a body continues to be in it state of rest or of uniform motion along a straight line until and unless it is compelled by an external force. From the statement , force can be defined as that which changes or tends to changes the state of rest or that of uniform motion.

Second law tells what happens when a force is actually exerted on a body. when a force acts an a body and there occurs a change in its momentum , then according to second law , the rate of change of momentum is proportional to the applied force and in its direction

III. a) A cycle wheel can be set in to rotation easily if force is applied at the rim rather than at a point near to the axis of rotation. (4)

Ans: Ability of a force to rotate a body depends on the magnitude of force and how for it is applied form the axis of rotation.
That is , T = r*F
Torque due to a force is the product of force and perpendicular distance of the line of action of force from the axis of rotation.

b)Differentiate between inertia and moment of inertia. (4)

Ans: Inertia is the inability of a body to change its original state by itself . Inertia is a measure of mass. A body at rest have inertia of rest and a body in motion have inertia of motion.
Moment of inertia is rotational inertia. Moment of inertia is the inability of a body to change its state from uniform rotational motion to rest or vice versa. It is measured as the product of the mass of the particle and the square of the distance of the particle from the axis of rotation.

IV. a) Give reason why a body weighs more at poles. (4)

Ans: Weight of a body is given by the equation F = Mg. Here g is the acceleration due to gravity.
$G=GM/R^2$
Where M is the mass and R the radius of the earth. Since the shape of earth is flattened at poles and bulging out at the equation ,radius of the earth is smaller at poles. Since g α $1/r^2$ , g is less at equator and comparatively more at the poles Hence body weighs more at the poles.

b)A cable is re placed by another of the same length and material but twice the diameter. Analyze how it effects the elongation under a given load.

Ans: Young's modulus $Y=\frac{FL}{Al}=\frac{FL}{\pi r^2\ l}$.
Since both cables have same length ,load and material, but diameter differs, the eg for elongation can be given as,
$l_1=\frac{FL}{\pi r_1^2 y}$ and $l_2=\frac{FL}{\pi r_2^2 y}$
Since $r_2=2r$, $l_1/l_2 = (2r_1)^2/r_1^2 = 4$
i.e. $l_1=4l_2$. Elongation becomes four times compared to the first cable.

PART-C

(Answer two full questions. Each question carries 15 marks)

V. a) Differentiate between dimensional, dimensional formula and dimensional equation with a suitable example. (3)

Ans: Dimension of a physical quantity is powers to which the fundamental units of mass, length and time must be raised to represent a derived unit of the quantity.
Dimensional formula is an expression which tell us which and how the physical quantity depends on the fundamental units.
Dimensional equation is the equation obtained when a physical quantity is equated to its Dimensional formula.
E.g.: velocity : dimension is zero in mass , +1 in length and -1 in time .dimensional formula is $LT^{-1}$.
Dimensional equation: $V=[M^{\circ}L^{1}T^{-1}]$

b) A body covers 120m in the $4^{th}$second.If it travels 240m in 8s ,calculate its acceleration, initial velocity and velocity at the end of $8^{th}$ second. (6)

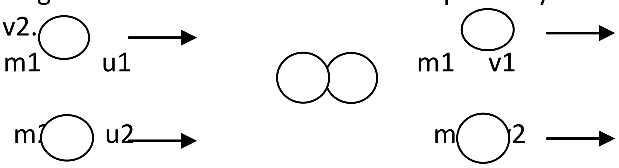
Ans: $S_n=u+a\ (n- ½\ )$
$120=u=a\ (4 – ½\ )$
$S=ut+ ½\ at^2$
$240=8u+ ½\ a(8)^2$.
The equations get simplified as, 240=2u+7a and 480=16u+64a
Solving, we get a= $-180m/s^2$, u=750m/s.
By 8 seconds, the distance covered by the body be $S=ut+ ½\ at^2$

S=750*8 + ½ (-180)*$8^2$ = 240m.
Using $v^2=u^2+2as = 750^2 - 2*180*240 = 476100$.
Therefore v=690 m/s.
I.e. by the end of 8 seconds, the body will have a velocity 690m/s.

c) A stone of mass 0.3kg is tied at the end of a string and whirled in a horizontal plane forming a circle of radius 1m with a speed of 40 revolutions per minute. What is the tension on the string? What is the linear velocity of string? (6)
Ans: M=0.3kg
R=1m
ω=40 rev/min= 40*2π rad/sec=4.2 rad/sec
Tension in the string = Centripetal force= $mr\omega^2$
Therefore Tension = 0.3*1*$4.2^2$= 5.29N
We have, $mv^2/r = T$
Therefore $v = \sqrt{\frac{T*r}{m}} = \sqrt{\frac{5.29*1}{0.3}} = 4.2m/s$

VI. a) When projected from horizontal at certain angle, a ball just passes over a pole at 10m height. Find the time taken by the ball to hit the ground. (3)
Ans: Here, the maximum height, $H=u^2Sin^2\Theta/2g$ =10m
$uSin\Theta = \sqrt{10*2g} = \sqrt{10*19.6} = \sqrt{196} = 14$
Time of flight, T=2uSinΘ/g
Substituting the value of uSinΘ.
T=2*14/g =2*14/9.8
T=2.86 s.

b) Demonstrate the conservation of linear momentum in collision of two bodies. If two masses 12kg and 8kg with velocities10m/s and 5m/s move together after collision. Find their common velocity. (6)
Ans: Law of conservation of momentum states that when two or more bodies collide, the sum of their momenta before impact is equal to the sum of momenta after impact.
Consider two bodies of masses m1 and m2 moving along a line with velocities u1 & u2 respectively.
After colliding for a time t,their velocities are v1 and v2.




Momentum of m2 before Collision = $m_2u_2$ .
Momentum of m2 after Collision = $m_2v_2$ .
Changes of momentum in t seconds = $m_2v_2 - m_2u_2$ .
Rate of change of momentum m2 = $m_2v_2-m_2u_2/t$.
A change of momentum will occur only by a force. In this case the force causing the change in momentum is action of the body $m_1$ on $m_2$.
Therefore
$$Action = \frac{m2v2 - m2u2}{t}$$
Change of momentum of first body in t seconds = $m_1v_1=m_1u_1$.
Rate of change of momentum of the first body =$m_1v_1-m_1u_1/t$.
This rate of change of first body is the reaction. Since action and reaction are equal and opposite.
$m_2v_2 - m_2u_2/t = -(m_1v_1-m_1u_1/t)$
$m_1u_1+m_2u_2=m_1v_1+m_2v_2$
i.e., total momentum before collision is equal to the total momentum after collision.
Here, m1=12kg, m2=8kg, u1=10m/s, u2=5m/s.
After collision, m=m1+m2=20kg.
Using law of conservation of momentum, m1u1+m2u2=MV

I.e. V= (m1u1+m2u2)/M = ((12*10)+(8*5))/20= 8m/s.

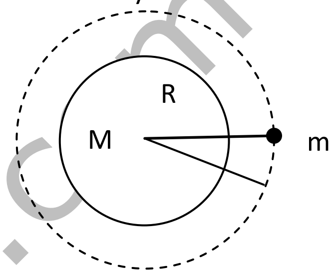
c) What is centripetal force? What is its relevance in the banking of a track? (6)

Ans: If a vehicle is moving along horizontal curve, the weight of the vehicle is balanced by the - normal reaction while the force of friction provides the centripetal force of friction provides the centripetal force. For the vehicle to turn without depending on the fractional force, the outer portion of the curved path is raised slightly above the inner. This process is called banking. Then a component of the normal reaction will contribute to the centripetal force. If v is the optimum speed and rather radius of the curve, the angle of banking 'θ' is given by,

$$\tan\theta = v^2/rg$$

b) Derive an expression for orbital velocity of a satellite (4)

Ans: The velocity with which a satellite moves in a closed orbit is called orbital velocity. Consider a satellite of mass m revolving around the earth of mass M and radius R. Let the satellite be revolving at a height h above the surface of the earth .the necessary centripetal force for rotation is provided by the gravitational force .if v is the velocity of the satellite ,




Centripetal force = $\frac{MV^2}{R+h}$ → (1)

Gravitational force = $\frac{GMM}{(R+h)^2}$ →(2)

Equating (1)&(2)

$$\frac{MV^2}{R+h} = \frac{GMM}{(R+h)^2}$$

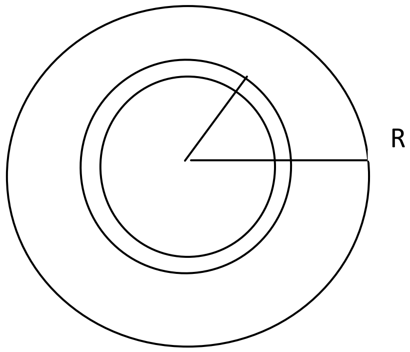
$V^2 = \frac{GM}{R+h}$ ➔ $\boxed{V = \sqrt{\frac{GM}{R+h}}}$ → (4)

$Eq^n$ (4) gives the $eq^n$ for orbital velocity

VII. a) Define radius of gyration. Determine the radius of gyration of a circular disc of radius R rotating about an axis passing through its center and perpendicular to its plane. (3)

Ans: If the whole mass M of a body is supposed to be concentrated at a point of distance 'K' from the axis such that $MK^2$ has the same axis , the length K is called radius of gyration

$$K = \sqrt{\frac{I}{M}}$$




Let M be the mass and R the radius of the disc. The disc R Can be imagined to be made up of a large number of rings of Small width and of gradually increasing radius from 0 to R. Consider such a ring of radius x and width dx.

Total mass of the disc = M.

Mass per unit area of the disc = $\frac{M}{\pi R^2}$

Area of the ring of radius x and width dx = 2πxdx

Mass of the ring = $2\pi x dx(\frac{M}{\pi R^2})$= 2xdx M/$R^2$.

Moment of inertia of this ring about the axis passing through the center and perpendicular to its plane is therefore $aMx^3dx/R^2$.Therefore the moment of inertia of the disc can be obtained by integrating between the limits x=0 to x=R. Thus,

$$I = \int_0^R (2M/R^2)\, x^3 dx$$

$$I = 2M/R^2 \int_0^R x^3 dx$$

$$I = 2M/R^2\, [x^4/4]_0^R$$

$$I = \frac{1}{2} MR^2$$

Since $I=MK^2$ and for a circular disc, about an axis perpendicular to its plane the moment of inertia is ½ $MR^2$, we have

$MK^2$ = ½ $MR^2$

$K = R/\sqrt{2}$

b) A disc of mass 1 kg with radius 0.5m is set to rotation in a horizontal plane about an axis passing vertically through its centre. If it makes 10 revolutions in 5 seconds. Determine the torque and rotational kinetic energy.

Ans: m=1 kg

r=0.5m

$\omega_2$=10 rev/5 sec = 2π rad/sec= 12.57 rad/sec

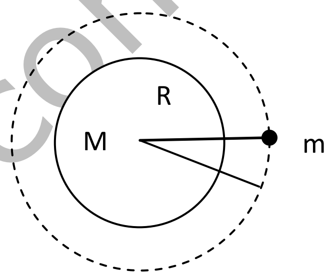
$\omega_1$=0 rad/sec

torque= Iα

For a disc, I= ½ mr$^2$= ½ *1*0.5$^2$ = 0.1250kgm$^2$

c) Deduce an expression for the orbital velocity of a satellite. What will be the velocity of the satellite if its orbit is close to the surface of earth? (6)

Ans: The velocity with which a satellite moves in a closed orbit is called orbital velocity. Consider a satellite of mass m revolving around the earth of mass M and radius R. Let the satellite be revolving at a height h above the surface of the earth .the necessary centripetal force for rotation is provided by the gravitational force .if v is the velocity of the satellite ,




Centripetal force = $\frac{MV^2}{R+h}$ → (1)

Gravitational force = $\frac{GMM}{(R+h)^2}$ →(2)

Equating (1)&(2)

$$\frac{MV^2}{R+h} = \frac{GMM}{(R+h)^2}$$

$$V^2 = \frac{GM}{R+h} \rightarrow \boxed{V = \sqrt{\frac{GM}{R+h}}} \rightarrow (4)$$

Eq$^n$ (4) gives the eq$^n$ for orbital velocity

When the satellite is revolving close to the earth, h=0. Then, $v_0 = \sqrt{\frac{GM}{R}} = \sqrt{gR}$

I.e. $v_0 = \sqrt{9.8 * 6400 * 10^3} = 7919.6\frac{m}{s} = 7.92 km/s$

VIII. a) Calculate the height at which geostationary satellite revolve above earth. g=9.8m/s$^2$, R=6400 km. (3)

Ans: For a geostationary satellite, $T = 2\pi\sqrt{\frac{(R+h)^3}{gR^2}}$

T=24 hrs = 864400s, g=9.8m/s$^2$, R=6400*10$^3$m

Therefore $864400 = 2\pi\sqrt{\frac{((6400*10^3)+h)^3}{9.8*(6400*10^3)^2}}$

Solving we get, h=35954 km.

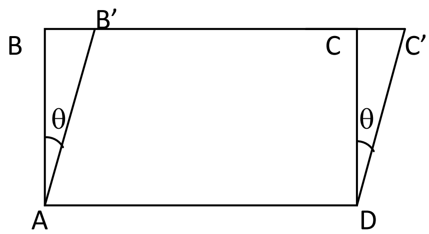
b) Deduce expressions for Young's modulus, rigidity modulus and bulk modulus. (6)

Ans: Young's modulus : It is ratio of the longitudinal stress to the longitudinal strain

$$Y = Longitudinal\ stress/Longitudinal\ strain = (F/A)/(l/L) = \frac{FL}{Al}$$

Rigidity modulus : It is the ratio of shearing stress to shearing strain

$$\eta = \frac{\frac{F}{A}}{\theta} = \frac{F}{A\theta}$$




Bulk Modulus : It is the ratio of the bulk stress to the strain

$$K = \frac{P}{\frac{v}{V}} = \frac{PV}{v}$$

c) A steel wire of length 4.m and cross-section $3*10^{-5}m^2$ stretches by the same amount as a copper wire of length 3.5m and cross-section $4*10^{-5}m^2$ under a given load. What is the ratio of Young's modulus of steel to that of copper? (6)

Ans: $L_s$=4.7m for steel

$A_s=3*10^{-5}m^2$

$L_c$ = 3.5m for copper

$A_c = 4*10^{-5}m^2$

L and F are the same for both. We know that Y=FL/Al.

$Y_s/ Y_c = (FL_s/ A_s l)*(A_c l/ FL_c) = L_s A_c/ A_s L_c = 1.79$