Short Answer Type Questions – I

Q.1. What is geocentric theory?

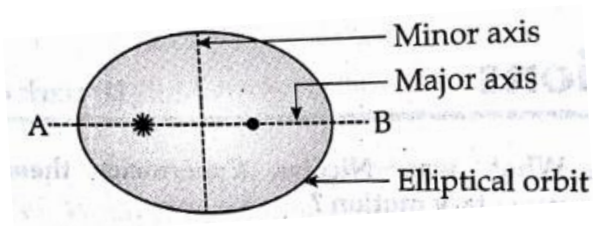
Ans. Ptolemy thought that sun as well as other stars revolved around earth. His theory was called geocentric theory. He said that the planets revolved in small circles known as epicycles whereas centers of these epicycle revolved around the earth in larger circles called deferents.

Q.2. What is meant by the Italian phrase ‘Epursi muove’?

Ans. It means ‘And still it moves’. Galileo whispered these words with reference to earth.

Q.3. What is Kepler’s heliocentric theory?

Ans. According to this theory, all plants revolve around the sun in elliptical orbits with sun as one of the foci.



Q.4. Define universal constant of gravitation. What is its value? Give its dimensional formula?

Ans. It is defined as the force of attraction acting between two bodies each of unit mass, whose centre are placed at unit distance apart. The value of G is constant throughout the universe. It is a scalar quantity. The dimensional formula of G = $[M^{-1}L^3T^{-2}]$. The value of G = 6.67×10^{-11} Nm^2kg^{-2}.The value of G being to small, we do not experience it in our daily life.

Q.5. State Kepler’s law of Planetary motion. Name the physical quantities which remain constant during the planetary motion, point without acceleration.

Ans. (a) Kepler’s I Law (Law of Orbits) : Each planet revolves around the Sun in an elliptical orbit. The sun is situated at one foci of the ellipse.

(b) Kepler’s II Law (Law of Areas) : The position vector of the planet from the Sun sweeps out equal area in equal interval of time. That is the areal velocity of the planet around the Sun is constant.

(c) Kepler’s III Law (Law of Periods) : The square of the time period of any planet about the Sun is proportional to the cube of the semi-major axis of the elliptical orbit.

(i) Mass
(ii) Angular Momentum
(iii) Total Energy

Q.6. (i) According to Kepler’s second law, the radius vector to a planet form the sun sweeps out equal area in equal interval of time. The law is consequence of which

conservation law?
(ii) State Kepler's third law.

Ans. (i) It is consequence of law of conservation of angular momentum.
(ii) The square of the time period of any planet about the Sun is proportional to the cube of the semi-major axis of the elliptical orbit.

Q.7. What is effect of shape of earth on g?

Ans. Earth is elliptical in shape. Radius of earth is at equator about 21 km more than its radius at pole. Using the relation $g = \frac{\mathrm{GM}}{\mathrm{R}^2}$.

We find that $g \propto \frac{1}{\mathrm{R}^2}$. Since radius at pole is less than that of equator, the value of g is more at pole.

Q.8. If the earth suddenly stops rotating about its axis, what would be the effect on the value of 'g'? Will this effect be same at all places?

Ans. The value of $'g'$ at a place on earth of latitude λ is $g' = g - \mathrm{R}\omega^2 cos^2\lambda$.

For any value of ω, $g' < g$. It means the value of $'g'$ decreases due to rotation of the earth. If earth stops rotating, the value of g would increase. The effect will be maximum at equator and least at pole.

Q.9. Gravitational force is a weak force but still it is considered the most important force. Why?

Ans. Gravitational force plays an important role for initiating the birth of stars, for controlling the entire structure of the universe and evolution of the universe. It helped to explain many natural phenomena.

Q.10. Is the value of g same everywhere on the surface of earth? How has it been decided?

Ans. No, the value of g is different at different places on the surface of earth. The shape of the earth is not exactly spherical, it is flattened at the poles and is bulging out at the equator. Due to which the radius of the earth is smaller at poles and is larger at equator. Since $g \propto 1/R^2$, therefore the acceleration due to gravity is smaller at equator than that at poles.

Q.11. Two particles of equal mass move in a circle of radius r under the action of their mutual gravitational attraction. Find the speed of each particle if its mass is m.

Ans. The two particles will move on a circular path if they always remain diametrically opposite to that the gravitational force on one particle due to other is directly along the radius.

Taking into consideration the circulation of the one particle, we have

Centripetal force = Gravitational force

$$\frac{mv^2}{r} = \frac{\mathrm{GM}m}{(2r)^2}$$

or $v = \sqrt{\frac{GM}{4r}}$

Q.12. Earth is continuously pulling moon towards its centre. Why does not moon fall on to earth?

Ans. It is so because the gravitational attraction of earth provides the necessary centripetal force to the moon for its orbital motion around the earth. Due to which the moon is revolving around the earth.

Q.13. Define gravitational potential. Give its S.I. Unit.

Ans. Gravitational potential at a point in a gravitational field of a body is defined as the amount of work done in bringing a body of unit mass from infinity to that point without acceleration. Its S.I. Unit is J-kg^{-1}.

Q.14. Define a satellite.

Ans. Satellite is a smaller body revolving around another heavier body in stable orbit, e.g., moon is satellite of earth, earth is satellite of sun.

Q.15. What is escape velocity? Give relation for the same.

Ans. The velocity required by the body to escape from the gravitational pull of the earth is called the escape velocity.

$$v_e = \sqrt{2gr} = \sqrt{2}v_o$$

where v_o is the orbital velocity.

Q.16. Name some Indian artificial satellites.

Ans. Aryabhatta, Bhaskara I, Rohini, APPLE, INSAT etc.

Q.17. Weight of a body should greater in dry or night. Why?

Ans. It should be greater in night. In the day time the body is pulled by earth and sun in two opposite directions. This will result into decrease in weight.

During night time the earth and the sun pull the body in the same direction so the weight will increase in night.

Q.18. Why oxygen escape slower from the atmosphere of earth than hydrogen?

Ans. Molecules of hydrogen escape the earth factor because their R.M.S. velocity is more than that of oxygen molecules, R.M.S. velocity is given by

$$r_{rms} \propto \frac{1}{\sqrt{m}}$$

where m is the mass of the molecules.

Mass of oxygen molecules is larger than hydrogen so its R.M.S> velocity is less than that of hydrogen. Thus, it escapes slower than hydrogen.

Q.19. What will happen if a satellite stops orbiting?

Ans. When a satellite stops orbiting, its kinetic energy becomes zero. This energy is converted into potential energy of the satellite. It then, starts falling towards the earth while crossing the atmosphere with great speed it may even burn.

Q.20. Will 1 kg sugar be more at poles or at the equator?

Ans. The value of g is larger at the poles than at the equator. If the sugar is weighed in a physical balance then there will be no difference. If it is weighed by a spring balance, calibrated at the equator, then 1 kg of sugar will have a lesser amount at poles.

Q.21. Why do different planets have different escape velocities?

Ans. As escape velocity = $\sqrt{\frac{2GM}{R}}$

Therefore its values are different for different planets which are of different masses and different sizes.

Q.22. What are the two factors which determine why some bodies in solar system have atmosphere and other don't have?

Ans. The ability of a body (planet) to hold the atmosphere depends on (i) acceleration due to gravity, and (ii) surface temperature.

Q.23. Does speed of satellite remain constant in an orbit? Explain.

Ans. If the orbital path of a satellite is circular, then its speed is constant and if the orbital path of a satellite is elliptical one then its speed in its orbit is not constant. In that case its areal velocity is constant.

Q.24. Why are space rockets usually launched from west to east in the equatorial line?

Ans. We know that earth revolves from west to east about its polar axis. Therefore, all the particles on the earth have velocity from the west to east. This velocity is maximum in the equatorial line, as $V = R\omega$, where R is the radius of earth and ω is the angular velocity of revolution of earth about its polar axis.

When a rocket is launched from west to east in equatorial plane, the maximum linear velocity is added to the launching velocity of the rocket, due to which launching becomes easier.

Q.25. If the diameter of earth becomes two times the present value and its mass remains unchanged; then how would the weight of an object on the surface of earth be affected?

Ans. Using $F = \frac{\mathrm{GM}m}{\mathrm{R}^2}$

we have new weight

given by $F' = \frac{\mathrm{GM}m}{(2\mathrm{R})^2} = \frac{1}{4}F$

∴ Weight becomes one-fourth of the original value.

Q.26. Two artificial satellites, one close to the surface and the other away are revolving around the earth, which has larger speed?

Ans. The relations for orbital velocity is

$$v_o = \sqrt{\frac{Gm}{(R+h)}}$$

Where h is the height of the satellite above the earth's surface. Clearly, the smaller is the value of h, greater is the value of v and vice-versa. Hence, satellite revolving close to earth has larger speed.

Q.27. If the earth satellite is put into an orbit at a height where resistance due to atmosphere, cannot be neglected, how will motion of satellite be affected?

Ans. Air resistance will reduce the orbital velocity of satellite. Hence, the satellite will ultimately fall back to the earth. Air resistance may also produce a lot of heat and the satellite may even burn.

Q.28. Which has longer period of revolution, a satellite revolving close or away from surface of earth?

Ans. We know that,

$(\text{Time period})^2 \propto (\text{Orbit radius})^3$.

Therefore, time period is larger in case of satellite revolving away from the surface of earth.

Q.29. If a person goes to a height equal to radius of earth from its surface, what would be his weight relative to that on the earth?

Ans. At the surface of earth, weight

$$w = mg = GMm/R^2$$

At height $h = R$,

weight $w' = mg'$

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

$\therefore \quad \frac{w'}{w} = \frac{R^2}{(2R)^2} = \frac{1}{4}$

or $\quad w' = \frac{w}{4}$

It means the weight would reduce to one-fourth of the weight on the surface of earth.

Q.30.A satellite of mass m is moving in a circular orbit of radius r round the earth. Calculate its angular momentum with respect to the centre of the orbit in terms of the mass M of the earth G.

Ans. Angular momentum of satellite,

$$L = mvr = mr\sqrt{\frac{GM}{r}}$$

$$= (m^2 GMr)^{\frac{1}{2}}$$

Q.31. Taking the moon's orbit around earth to be r and mass of earth 81 times the mass of the moon. Find the position of the point from the earth, where the net gravitational field intensity is zero?

Ans. Let x be the distance of a point from the earth where resultant gravitational field intensity is zero.

So $$\frac{\mathrm{GM}_e m}{x^2} = \frac{\mathrm{GM}_m m}{(r-x)^2}$$

or, $$\frac{81\mathrm{GM}_m m}{x^2} = \frac{\mathrm{GM}_m m}{(r-x)^2}$$

or, $$\frac{9}{x} = \frac{1}{(r-x)}$$

or, $$9r = 10x$$

or, $$x = \left(\frac{6}{10}\right) r = 0.9r$$

Q.32. Two satellites A and B go round a planet pin circular orbits having radius 4R and R respectively. If the speed of the satellite A is $3v$, find the speed of the satellite B.

Ans. As, $$v_o = \sqrt{\frac{\mathrm{GM}}{\mathrm{R}}}$$

So, For A $$3v = \sqrt{\frac{\mathrm{GM}}{4\mathrm{R}}} \quad \ldots(1)$$

And for B $$v' = \sqrt{\frac{\mathrm{GM}}{\mathrm{R}}} \quad \ldots(2)$$

Dividing (2) by (1) we get,

∴ $$\frac{v'}{3v} = 2$$

or $$v' = 6v$$

Q.33. Is it possible to put an artificial satellite into an orbit in such a way that it will always remain directly over New Delhi? (a place which is not on the equatorial plane)?

Ans. Not possible, because a satellite will appear stationary only when it revolves in an orbit concentric and coplanar with the equatorial plane having time period of revolution 24 hours and it should have the sense of revolution from west to east that of earth. As New Delhi is not in the equatorial plane, hence it will not be possible to put a geostationary satellite over New Delhi.

Q.34. The distance of planet Jupiter from the sun is 5.2 times that of the earth. Find the period of revolution of Jupiter around the sun.

Ans. Here, $r_{\mathrm{J}} = 5.2r_e$

$\mathrm{T_J} = ?$

$\mathrm{T}_e = 1$ year

Now $$\frac{T_J^2}{T_J^2} = \frac{r_J^3}{r_e^3}$$

or, $$T_J = T_e\left(\frac{r_J}{r_e}\right)^{\frac{3}{2}}$$

$$= 1 \times \left(\frac{5.2r_e}{r_e}\right)^{\frac{3}{2}}$$

= 11.86 years

Q.35. Find the height from the surface of earth at which weight of a body of mass m reduced to 36% of its weight on the surface. ($\mathbf{R}_e = \mathbf{6400\ km}$.)

Ans. h =?, R = 6400 km

$$g' = g\left(1 - \frac{2h}{R}\right) = g - \frac{2gh}{R}$$

or $$g - g' = \frac{2gh}{R}$$

Percentage decrease in weight

$$= \frac{mg - mg'}{mg} \times 100$$

$$= \frac{g - g'}{g} \times 100$$

$$\frac{g - g'}{g} \times 100 = \frac{2gh}{gR} \times 100$$

$$= \frac{2h}{R} \times 100$$

$$36 = \frac{2 \times h}{6400} \times 100$$

or $$h = 1.152 \text{ km}$$

Q.36. If suddenly the gravitational force of attraction between the earth and a satellite revolving around it becomes zero, what will happen to the satellite.

Ans. Motion of the satellite around earth will also be not possible as no centripetal force will be provided.

Q.37. Planet Mars has two moons, phobos and delmos. Phobos has a period of 7 hours 39 minutes and orbital radius of 9.4 × 10^3 km. Calculate the mass of Mars. (G = 6.67 × 10^{-11} Nm^2-kg^{-2})

Ans. We have,

$$T^2 = \frac{4\pi^2}{GM m}R^3$$

or $$M_m = \frac{4\pi^2}{G} \cdot \frac{R^3}{T^2}$$

∴ $$M_m = \frac{4\times(3.15)^2\times(9.4\times10^3)^3}{6.67\times10^{-11}\times(459\times60)^2}$$

$$= 6.48 \times 10^{23} \text{ kg}$$

Q.38. A black hole is a body from whose surface nothing ever escape. What is the condition for a uniform spherical mass m to be a black hole? What should be the radius of such a black hole if its mass is the same as that of earth?

Ans. From Einstein's special theory of relativity, we know that the speed of light, $c = (3 \times 10^8\ ms^{-1})$ cannot be exceeded by any moving particle. Thus c is the upper limit to the projectile escape speed.

i.e., $$v_e = \left(\frac{2GM}{R}\right)^{\frac{1}{2}} \leq e$$

if $$M = M_e,$$

then $$R = \frac{2GMe}{c^2}$$

$$= \frac{2\times(6.67\times10^{-11})\times(6\times10^{24})}{(3\times10^8)^2}$$

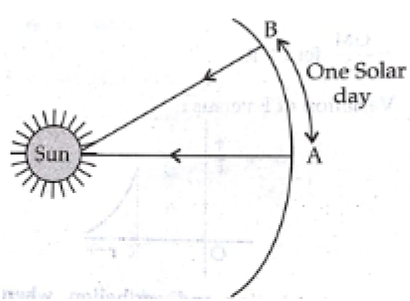
$$= 8.9 \times 10^{-3}\text{m} = 1 \text{ cm}$$

It means the earth can act as a black hole. If it shrinks to a very small size of nearby 1 cm radius, which is the size of a berry.

Q.39. Mean solar day is the time interval between two successive noon when sun passes through zenith point (meridian).
Sidereal day is the time interval between two successive transit of a distant star through the zenith point (meridian).
By drawing appropriate diagram showing earth's spin and orbital motion, show that mean solar day is 4 minutes longer than the sidereal day. In other words, distant stars would rise 4 minutes early every successive day.

(Hint : you may assume circular orbit for the earth).

Ans. Let us consider the following diagram, the earth moves from the point A to B in one solar day.



Every day the earth advances in the orbit by approximately 1°. Then, it will have to rotate by 361° (which we define as 1 day) to have sun at zenith point again. Since 361° corresponds to 24 hours.

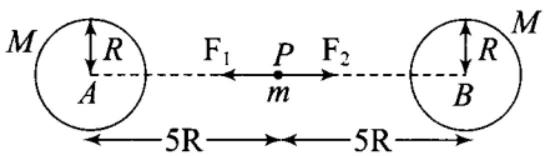
∴ Extra 1° corresponds to approximately 4 minutes [3 min 59 seconds].

i.e. $\frac{24}{361} \times 1 = 0.666h = 3.99$ min = 4 min

Thus, distant stars would rise 4 minutes early every successive day.

Q.40. Two identical heavy spheres are separated by a distance 10 times their radius. Will an object placed at the mid-point of the line joining their centres be in stable equilibrium or unstable equilibrium? Give reason for your answer.

Ans. Given: $m_1 = m_2 = \mathrm{M}, r = 10\mathrm{R}$



Let mass m is placed at mid-point A (line joining the centres of P & Q sphere)

Now, $|\mathrm{F}_2| = |\mathrm{F}_1| = \frac{\mathrm{GM}m}{(5\mathrm{R})^2}$

$|\mathrm{F}_2| = |\mathrm{F}_1| = \frac{\mathrm{GM}m}{25\mathrm{R}^2}$

$\mathrm{F}_1 \& \mathrm{F}_2$ are equal and opposite forces are acting on m at A.

Net force $\mathrm{F}_1 = -\mathrm{F}_2$ or $\mathrm{F}_1 + \mathrm{F}_2 = 0$

So, mass is in equilibrium.

If m is slightly displaced from A to P then

AP = (5R – x)

AQ = (5R + x)

∴ $\mathrm{F}_1 = \frac{\mathrm{GM}m}{(5\mathrm{R}-x)^2}$ & $\mathrm{F}_2 = \frac{\mathrm{GM}m}{(5\mathrm{R}+x)^2}$ or $\mathrm{F}_1 > \mathrm{F}_2$

That means resultant force acting on A is towards P. Hence, equilibrium is unstable equilibrium.

Q.41. Show the nature of the following graph for a satellite orbiting the earth.

(a) KE versus orbital radius R
(b) PE versus orbital radius R
(c) TE versus orbital radius R

Ans. Mass of earth = M_e

Mass of satellite = m

Radius of orbit of satellite = R

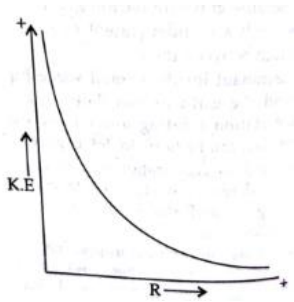
Orbital Velocity $\mathrm{v}_o = \sqrt{\frac{\mathrm{GM}}{\mathrm{R}}}$

(a) K.E. versus orbital radius R

K.E. $= \frac{1}{2} m m_0^2 = \frac{1}{2} m . \frac{\mathrm{GM}}{\mathrm{R}}$

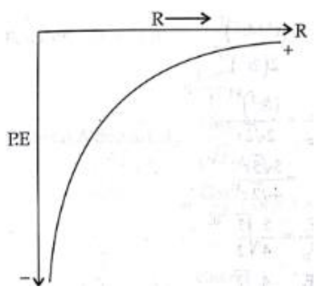
$= \frac{\mathrm{GM}m}{2\mathrm{R}}$

K.E. $\propto \frac{1}{\mathrm{R}}$ (It decreases with R)



(b) P.E. versus orbital radius R.

P.E. = $-\frac{\mathrm{GM}m}{\mathrm{R}}$ or P.E. $\propto \frac{-1}{\mathrm{R}}$

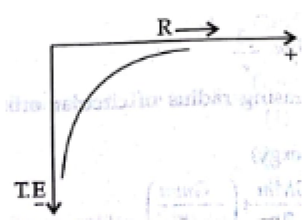


(c) Total energy versus Orbital radius R

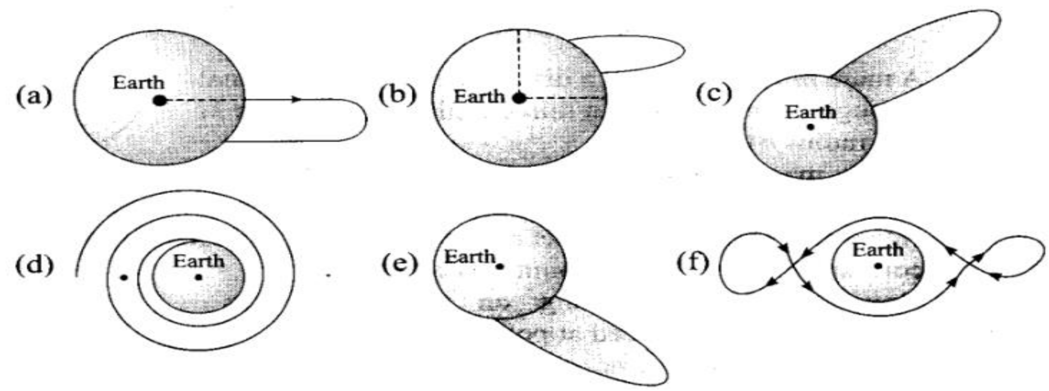
K.E. $= +\frac{1}{2}\frac{\mathrm{GM}m}{\mathrm{R}}, P.E. = \frac{-\mathrm{GM}m}{\mathrm{R}}$

T.E. $= \frac{1}{2}\frac{\mathrm{GM}m}{\mathrm{R}} - \frac{\mathrm{GM}m}{\mathrm{R}}$

T.E. $= -\frac{1}{2}\frac{\mathrm{GM}m}{\mathrm{R}}$



Q.42. Shown are several curves (Fig (a), (b), (c) ,(d), (e) and (f), Explain with reason which ones amongst them can be possible trajectories traced by a projectile (neglect air friction)



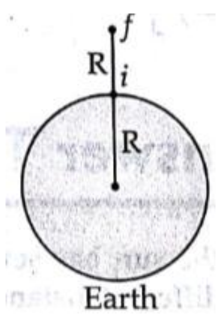
Ans. The trajectory of particle under gravitational force of the earth will be a conic section (for motion outside the earth) with the centre of the earth as a focus. Only (c) meets this requirement because in which centre of earth is the focus of trajectory.

Q.43. An object of mass m is raised from the surface of the earth to a height of equal to the radius of the earth, that is, taken from a distance R to 2R from the centre of the earth. What is the gain in its potential energy?

Ans. Given : An object is raised distance R → 2R

Potential energy of body on the surface of earth = $\frac{-GMm}{R}$

P.E. of object at height equal to radius of earth = $\frac{-GMm}{2R}$



Gain in Potential Energy= $P.E_f - P.E_i$

$$= \frac{GMm}{R} — GMmR$$

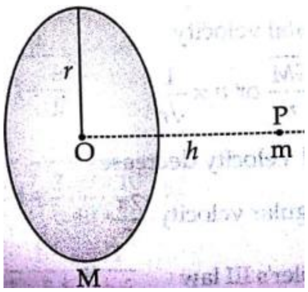
$$= \frac{GMm}{R}\left[-\frac{1}{2} + 1\right]$$

$$= \frac{GMm}{2R}$$

As, $GM = gR^2$

Gain in P.E. = $\frac{gR^2m}{2R} = \frac{1}{2}mgR.$

Q.44. A mass m is placed at P a distance h along the normal through the centre O of a thin circular ring of mass M and radius r (figure).

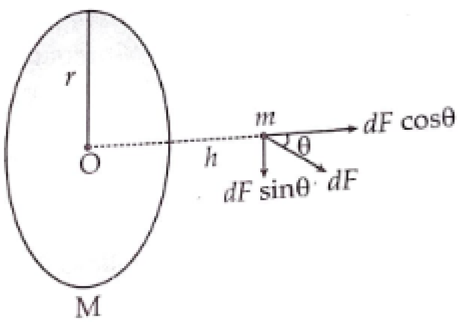


If the mass is moved further away such that OP becomes 2h, by what factor the force of gravitation will decrease, if h = r?

Ans. Gravitational force F at P

$$F_h = \frac{GMm\cos\theta}{AP^2} = \frac{GMhh}{(r^2+h^2)^{3/2}}$$

$\because$ cos θ = $\frac{h}{(r^2+h^2)^{\frac{1}{2}}}$



$$\frac{F_r}{F_{2r}} = \frac{\frac{GMm.r}{(r^2+r^2)^{3/2}}}{\frac{GMm2r}{[r^2+(2r)^2]^{3/2}}}$$

or $\quad \frac{(r^2+4r^2)^{\frac{3}{2}}}{2(2r^2)^{\frac{3}{2}}}$

$$\frac{F_r}{F_{2r}} = \frac{(5r^2)^{3/2}}{2\sqrt{2}r^3}$$

$$= \frac{5\sqrt{5}r^3}{4\sqrt{2}r^3}$$

$$\frac{F_r}{F_{2r}} = \frac{5}{4}\sqrt{\frac{5}{2}}$$

or $\frac{F_{2r}}{F_r} = \frac{4}{5}\sqrt{\frac{2}{5}}$

or $F_{2r} = \frac{4}{5}\sqrt{\frac{2}{5}}F_r$