DPP - Daily Practice Problems

Name : ______ Date : ______

Start Time : ______ End Time : ______

PHYSICS 18

SYLLABUS : Gravitation - 1 (The Universal law of gravitation, Acceleration due to gravity and its variation with altitude and depth, Kepler's law of planetary motion)

Max. Marks : 116 **Time : 60 min.**

GENERAL INSTRUCTIONS

- The Daily Practice Problem Sheet contains 29 MCQ's. For each question only one option is correct. Darken the correct circle/ bubble in the Response Grid provided on each page.
- You have to evaluate your Response Grids yourself with the help of solution booklet.
- Each correct answer will get you 4 marks and 1 mark shall be deduced for each incorrect answer. No mark will be given/ deducted if no bubble is filled. Keep a timer in front of you and stop immediately at the end of 60 min.
- The sheet follows a particular syllabus. Do not attempt the sheet before you have completed your preparation for that syllabus. Refer syllabus sheet in the starting of the book for the syllabus of all the DPP sheets.
- After completing the sheet check your answers with the solution booklet and complete the Result Grid. Finally spend time to analyse your performance and revise the areas which emerge out as weak in your evaluation.

DIRECTIONS (Q.1-Q.20) : There are 20 multiple choice questions. Each question has 4 choices (a), (b), (c) and (d), out of which **ONLY ONE** choice is correct.

Q.1 A mass M splits into two parts m and (M – m), which are then separated by a certain distance. What ratio of (m / M) maximises the gravitational force between the parts. ?

(a) 2/3 (b) 3/4

(c) 1/2 (d) 1/3

Q.2 What would be the angular speed of earth, so that bodies lying on equator may experience weightlessness ? ($g = 10 m/s^2$ and radius of earth = 6400 km)

(a) 1.25×10^{-3} rad/sec (b) 1.25×10^{-2} rad/sec

(c) 1.25×10^{-4} rad/sec (d) 1.25×10^{-1} rad/sec

Q.3 The speed with which the earth have to rotate on its axis so that a person on the equator would weigh (3/5) th as much as present will be -
(Take the equatorial radius as 6400 km.)

(a) 3.28×10^{-4} rad/sec (b) 7.826×10^{-4} rad/sec

(c) 3.28×10^{-3} rad/sec (d) 7.28×10^{-3} rad/sec

Q.4 On a planet (whose size is the same as that of earth and mass 4 times to the earth) the energy needed to lift a 2kg mass vertically upwards through 2m distance on the planet is ($g = 10 m/sec^2$ on the surface of earth) -

(a) 16 J (b) 32 J (c) 160 J (d) 320 J

Q.5 Two bodies of mass 10^2 kg and 10^3 kg are lying 1m apart. The gravitational potential at the mid-point of the line joining them is -

(a) 0 (b) –1.47 Joule/kg

(c) 1.47 Joule/kg (d) -147×10^{-7} Joule /kg

RESPONSE GRID	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ	3. ⓐⓑⓒⓓ	4. ⓐⓑⓒⓓ	5. ⓐⓑⓒⓓ

Space for Rough Work

Q.6 If g is the acceleration due to gravity on the earth's surface, the gain in P.E. of an object of mass m raised from the surface of the earth to a height of the radius R of the earth is -

(a) mgR (b) 2mgR (c) $\frac{1}{2}$ mgR (d) $\frac{1}{4}$ mgR

Q.7 Four particles, each of mass m, are placed at the corners of square and moving along a circle of radius r under the influence of mutual gravitational attraction. The speed of each particle will be -

(a) $\sqrt{\frac{Gm}{r}(2\sqrt{2}+1)}$ (b) $\sqrt{\frac{Gm}{r}}$

(c) $\sqrt{\frac{Gm}{r}\left(\frac{2\sqrt{2}+1}{4}\right)}$ (d) $\sqrt{\frac{2\sqrt{2}Gm}{r}}$

Q.8 Three particles of equal mass m are situated at the vertices of an equilateral triangle of side l. What should be the velocity of each particle, so that they move on a circular path without changing l ?

(a) $\sqrt{\frac{GM}{2\ell}}$ (b) $\sqrt{\frac{GM}{\ell}}$ (c) $\sqrt{\frac{2GM}{\ell}}$ (d) $\sqrt{\frac{GM}{3\ell}}$

Q.9 What will be the acceleration due to gravity on the surface of the moon if its radius is 1/4 th the radius of the earth and its mass is 1/80 th the mass of the earth ?

(a) g/6 (b) g/5 (c) g/7 (d) g/8

Q.10 If the value of 'g' at a height h above the surface of the earth is the same as at a depth x below it, then (both x and h being much smaller than the radius of the earth)

(a) $x = h$ (b) $x = 2h$ (c) $x = \frac{h}{2}$ (d) $x = h^2$

Q.11 At what height above the earth's surface the acceleration due to gravity will be 1/9 th of its value at the earth's surface? Radius of earth is 6400 km.

(a) 12800 km (b) 1280 km
(c) 128000 km (d) 128 km

Q.12 If the radius of the earth were to shrink by one percent, its mass remaining the same, the acceleration due to gravity on the earth's surface would -

(a) decrease (b) remain unchanged
(c) increase (d) None of these

Q.13 At what height above the earth's surface does the force of gravity decrease by 10% ? Assume radius of earth to be 6370 km.

(a) 350 km. (b) 250 km. (c) 150 km. (d) 300 km.

Q.14 A particle is suspended from a spring and it stretches the spring by 1 cm on the surface of earth. The same particle will stretches the same spring at a place 800 km above earth surface by -

(a) 0.79 cm (b) 0.1 cm
(c) $\pi/6$ rad/hr. (d) $2\pi/7$ rad/hr.

Q.15 The change in the value of acceleration of earth towards sun, when the moon comes from the position of solar eclipse to the position on the other side of earth in line with sun is (Mass of moon = 7.36×10^{22} kg, the orbital radius of moon 3.8×10^8m.

(a) 6.73×10^{-2} m/s^2 (b) 6.73×10^{-3} m/s^2
(c) 6.73×10^{-4} m/s^2 (d) 6.73×10^{-5} m/s^2

Q.16 The radius of the earth is R_e and the acceleration due to gravity at its surface is g. The work required in raising a body of mass m to a height h form the surface of the earth will be -

(a) $\frac{mgh}{\left(1-\frac{h}{R_e}\right)}$ (b) $\frac{mgh}{\left(1+\frac{h}{R_e}\right)^2}$ (c) $\frac{mgh}{\left(1+\frac{h}{R_e}\right)}$ (d) $\frac{mg}{\left(1+\frac{h}{R_e}\right)}$

Q.17 The masses and the radius of the earth and the moon are M_1, M_2 and R_1, R_2 respectively their centres are at distance d apart. The minimum speed with which a particle of mass m should be projected form a point midway between the two centres so as to escape to infinity will be -

(a) $2\sqrt{\frac{G}{d}(M_1+M_2)}$ (b) $\sqrt{\frac{G}{d}(M_1+M_2)}$

(c) $\sqrt{\frac{G}{2d}(M_1+M_2)}$ (d) $2\sqrt{\frac{G\,M_1}{d\,M_2}}$

Q.18 With what velocity must a body be thrown upward form the surface of the earth so that it reaches a height of 10 R_e? earth's mass $M_e = 6 \times 10^{24}$ kg, radius $R_e = 6.4 \times 10^6$ m and $G = 6.67 \times 10^{-11}$ N–m^2/kg^2.

(a) 10.7×10^4 m/s (b) 10.7×10^3 m/s
(c) 10.7×10^5 m/s (d) 1.07×10^4 m/s

RESPONSE GRID					
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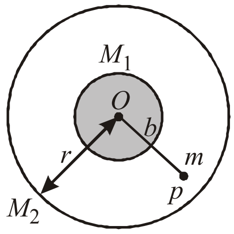
	11. ⓐⓑⓒⓓ	12. ⓐⓑⓒⓓ	13. ⓐⓑⓒⓓ	14. ⓐⓑⓒⓓ	15. ⓐⓑⓒⓓ
	16. ⓐⓑⓒⓓ	17. ⓐⓑⓒⓓ	18. ⓐⓑⓒⓓ		

Space for Rough Work

Q.19 Two concentric shells of uniform density having masses M_1 and M_2 are situated as shown in the figure. The force on the particle of mass m when it is located at $r = b$ is



(a) $\frac{GM_1m}{b^2}$ (b) $\frac{GM_2m}{b^2}$

(c) $G\frac{(M_1+M_2)m}{b^2}$ (d) $G\frac{(M_1-M_2)m}{b^2}$

Q.20 What is the mass of the planet that has a satellite whose time period is T and orbital radius is r?

(a) $\frac{4\pi^2r^3}{GT^2}$ (b) $\frac{3\pi^2r^3}{GT^2}$ (c) $\frac{4\pi^2r^3}{GT^3}$ (d) $\frac{4\pi^2T}{GT^2}$

DIRECTIONS (Q.21-Q.23) : In the following questions, more than one of the answers given are correct. Select the correct answers and mark it according to the following codes:

Codes :

(a) 1, 2 and 3 are correct **(b)** 1 and 2 are correct
(c) 2 and 4 are correct **(d)** 1 and 3 are correct

Q.21 The gravitational force between two point masses m_1 and m_2 at separation r is given by $F = k\frac{m_1m_2}{r^2}$

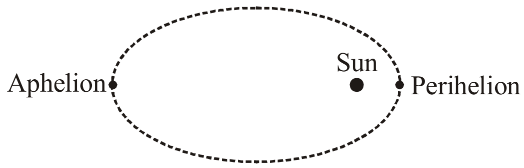
The constant k doesn't
(1) depend on medium between masses
(2) depend on the place
(3) depend on time
(4) depend on system of units

Q.22 Which of the following statements about the gravitional constant are false ?
(1) It is a force
(2) It has no unit
(3) It has same value in all system of units
(4) It doesn't depend on the value of the masses

Q.23 Spot the correct statements :
The acceleration due to gravity 'g' decreases if
(1) We go down from the surface of the earth towards its centre
(2) We go up from the surface of the earth
(3) The rotational velocity of the earth is increased
(4) We go from the equator towards the poles on the surface of the earth

DIRECTIONS (Q.24-Q.26) : Read the passage given below and answer the questions that follows :

The orbit of Pluto is much more eccentric than the orbits of the other planets. That is, instead of being nearly circular, the orbit is noticeably elliptical. The point in the orbit nearest to the sun is called the perihelion and the point farthest from the sun is called the aphelion.



Q.24 At perihelion, the gravitational potential energy of Pluto in its orbit has
(a) its maximum value
(b) its minimum value
(c) the same value as at every other point in the orbit
(d) value which depends on sense of rotation

Q.25 At perihelion, the mechanical energy of Pluto's orbit has
(a) its maximum value
(b) its minimum value
(c) the same value as at every other point in the orbit
(d) value which depends on sense of rotation

Q.26 As Pluto moves from the perihelion to the aphelion, the work done by gravitational pull of Sun on Pluto is
(a) is zero
(b) is positive
(c) is negative
(d) depends on sense of rotation

RESPONSE GRID					
	19. ⓐⓑⓒⓓ	20. ⓐⓑⓒⓓ	21. ⓐⓑⓒⓓ	22. ⓐⓑⓒⓓ	23. ⓐⓑⓒⓓ
	24. ⓐⓑⓒⓓ	25. ⓐⓑⓒⓓ	26. ⓐⓑⓒⓓ		

Space for Rough Work

DIRECTIONS (Q. 27-Q.29) : Each of these questions contains two statements: Statement-1 (Assertion) and Statement-2 (Reason). Each of these questions has four alternative choices, only one of which is the correct answer. You have to select the correct choice.

(a) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(b) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1.
(c) Statement -1 is False, Statement-2 is True.
(d) Statement -1 is True, Statement-2 is False.

Q.27 **Statement-1 :** Gravitational force between two particles is negligibly small compared to the electrical force.
Statement-2 : The electrical force is experienced by charged particles only.

Q.28 **Statement-1 :** The universal gravitational constant is same as acceleration due to gravity.
Statement-2 : Gravitional constant and acceleration due to gravity have different dimensional formula.

Q.29 **Statement-1 :** There is no effect of rotation of earth on the value of acceleration due to gravity at poles.
Statement-2 : Rotation of earth is about polar axis.

RESPONSE GRID	27. ⓐⓑⓒⓓ	28. ⓐⓑⓒⓓ	29. ⓐⓑⓒⓓ

DAILY PRACTICE PROBLEM SHEET 18 - PHYSICS			
Total Questions	29	Total Marks	116
Attempted		Correct	
Incorrect		Net Score	
Cut-off Score	30	Qualifying Score	48
Success Gap = Net Score – Qualifying Score			
Net Score = (Correct × 4) – (Incorrect × 1)			

Space for Rough Work

DAILY PRACTICE PROBLEMS

PHYSICS SOLUTIONS 18

(1) (c) If r is the distance between m and (M – m), the gravitational force will be -

$$F = G\frac{m(M-m)}{r^2} = \frac{G}{r^2}(mM - m^2)$$

The force will be maximum if, $\frac{dF}{dm} = 0$

i.e, $\frac{d}{dm}\left[\frac{G}{r^2}(mM - m^2)\right] = 0$

or $\frac{m}{M} = \frac{1}{2}$ (as M and r are constants)

(2) (c) $m_g = \sqrt{3}$ kg, $v = \frac{c}{2}$

$$m = \frac{m_0}{\sqrt{1-(v^2/c^2)}} = \frac{\sqrt{3}}{\sqrt{1-\frac{c^2}{4xc^2}}} = \frac{\sqrt{3}}{\frac{\sqrt{3}}{2}} \text{ kg}$$

(3) (a) $g' = g - R_e\omega^2$ (at equator $\lambda = 0$)
If a body is weightless,
$g' = 0$, $g - R_e\omega^2 = 0$

$$\Rightarrow \omega = \sqrt{\frac{g}{R}} = \sqrt{\frac{10}{6400 \times 10^3}} = 1.25 \times 10^{-3} \text{ rad/sec.}$$

(4) (b) The apparent weight of person on the equator (latitude $\lambda = 0$) is given by
$W' = W - m R_e\omega^2$,

$$W' = \frac{3}{5} W = \frac{3}{5} mg$$

$$\frac{3}{5} mg = mg - mR\omega^2 \text{ or } mR\omega^2 = mg - \frac{3}{5} mg$$

$$\omega = \sqrt{\frac{2}{5}\frac{g}{R}} = \sqrt{\frac{2}{5} \times \frac{9.8}{6400 \times 10^3}} \text{ rad/ sec}$$

$= 7.826 \times 10^{-4}$ rad/sec

(5) (c) According to question,

$g' = \frac{G \times 4M_p}{R_p^2}$ on the planet and $g = \frac{GM_e}{R_e^2}$ on the earth

$\because R_p = R_e$ and $M_p = M_e$

Now, $\frac{g'}{g} = 4 \Rightarrow g' = 4g = 40$ m/sec^2

Energy needed to lift 2 kg mass through 2m distance
$= mg'h = 2 \times 40 \times 2 = 160$ J

(6) (d) $V_g = V_{g1} + V_{g2} = -\frac{Gm_1}{r_1} - \frac{Gm_2}{r_2}$

$$= -6.67 \times 10^{-11}\left[\frac{10^2}{0.5} + \frac{10^3}{0.5}\right] = -1.47 \times 10^{-7} \text{ Joule/kg}$$

(7) (c) The P.E. of the object on the surface of earth is

$$U_1 = -\frac{GMm}{R}$$

The P.E. of object at a height R, $U_2 = -\frac{GMm}{(R+R)}$

The gain in P E is $U_2 - U_1 = \frac{GMm}{2R} = \frac{1}{2} mgR$

$$\left[\because g = \frac{GM}{R^2} \text{ on surface of earth}\right]$$

(8) (c) Resultant force on particle '1'

$F_r = \sqrt{2}\, F + F'$

or $F_r = \sqrt{2}\frac{Gm^2}{2r^2} + \frac{Gm^2}{4r^2} = \frac{mv^2}{r}$

or $v = \sqrt{\frac{Gm}{r}\left(\frac{2\sqrt{2}+1}{4}\right)}$

(9) (b) The resultant gravitational force on each particle provides it the necessary centripetal force

$$\therefore \frac{mv^2}{r} = \sqrt{F^2 + F^2 + 2F^2\cos 60^o} = \sqrt{3}F,$$

But $r = \frac{\sqrt{3}}{2}\ell \times \frac{2}{3} = \frac{\ell}{\sqrt{3}}$

$\therefore v = \sqrt{\frac{GM}{\ell}}$

(10) (b) The acceleration due to gravity on the surface of the earth, in terms of mass M_e and radius R_e of earth, is given by $g = \frac{GM_e}{R_e^2}$

if M_m be the mass of the moon, R_m its radius, then the acceleration due to gravity on the surface of the moon will be given by $g' = \frac{GM_m}{R_m^2}$

Dividing eq. (ii) by eq. (i), we get

$$\frac{g'}{g} = \frac{M_m}{M_e}\left(\frac{R_e}{R_m}\right)^2 = \frac{1}{80} \times \left(\frac{4}{1}\right)^2 = \frac{1}{5}$$

$\therefore g' = g/5$.

(11) (b) The value of g at the height h from the surface of earth

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

The value of g at depth x below the surface of earth

$$g' = g\left(1 - \frac{x}{R}\right)$$

These two are given equal, hence $\left(1-\frac{2h}{R}\right)=\left(1-\frac{x}{R}\right)$

On solving, we get $x = 2h$

(12) (a) If g be the acceleration due to gravity at the surface of the earth, then its value at a height h above the earth's surface will be -

$$g' = \frac{g}{\left(1+\frac{h}{R_e}\right)^2} \qquad \text{Here } \frac{g'}{g}=\frac{1}{9}$$

$$\therefore \frac{1}{9}=\frac{1}{\left(1+\frac{h}{R_e}\right)^2} \text{ or } 1+\frac{h}{R_e}=3$$

or $h = 2\,R_e = 2 \times 6400 = 12800$ km.

(13) (c) Consider the case of a body of mass m placed on the earth's surface (mass of the earth M and radius R). If g is acceleration due to gravity, then

$$mg = G\frac{M_e m}{R^2} \text{ or } g=\frac{GM_e}{R^2}$$

where G is universal constant of gravitation.
Now when the radius is reduced by 1%, i.e., radius becomes 0.99 R, let acceleration due to gravity be g',

then $g' = \frac{GM_e}{(0.99R)^2}$

From equation (A) and (B), we get

$$\frac{g'}{g}=\frac{R^2}{(0.99R)^2}=\frac{1}{(0.99)^2}$$

$$\therefore g' = g \times \left(\frac{1}{0.99}\right)^2 \text{ or } g' > g$$

Thus , the value of g is increased.

(14) (a) Force of gravity at surface of earth,
$F_1 = Gm\,M/R^2$ .... (1)
Force of gravity at height H is
$F_2 = Gm\,M\,(R+H)^2$ .... (2)
Dividing (A) by (B) and Rearranging

$$H = R\left(\sqrt{\frac{F_1}{F_2}}-1\right) = 350 \text{ km where } (F_2 = .9F_1)$$

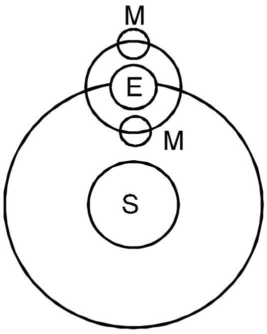
(15) (a) The extension in the length of spring is

$$x = \frac{mg}{k} = \frac{GMm}{r^2 k},$$

$$\therefore x \propto \frac{1}{r^2}, \quad \therefore \frac{x_2}{x_1}=\frac{R^2}{(R+h)^2}$$

or $x_2 = 1 \times \left(\frac{6400}{7200}\right)^2 = 0.79$ cm .

(16) (d) In the position of solar eclipse, net force on earth
$F_E = F_M + F_S$
In the position of lunar eclipse, net force on earth
$F'_E = F_S - F_M$



$\therefore$ Change in acceleration of earth,

$$\Delta f = \frac{2GM}{R^2} = \frac{2 \times 6.67 \times 10^{-11} \times 7.36 \times 10^{22}}{3.82^2 \times 10^{16}}$$

$= 6.73 \times 10^{-5}$ m/s^2

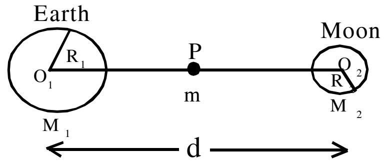
(17) (c) Let M_e be the mass of the earth. The work required

$$W = GM_e m\left[\frac{1}{R_e}-\frac{1}{R_e+h}\right]$$

$$= \frac{GM_e mh}{R_e(R_e+h)} = \frac{gR_e^2\, mh}{R_e(R_e+h)} \quad [\because GM_e = gR_e^2]$$

$$= \frac{mgh}{\left(1+\frac{h}{R_e}\right)}$$

(18) (a) The P.E of the mass at d/2 due to the earth and moon is



$$U = -2\frac{GM_1 m}{d} - 2\frac{GM_2 m}{d}$$

or $U = -\frac{2Gm}{d}(M_1+M_2)$ (Numerically)

$$\frac{1}{2}mV_e^2 = U \Rightarrow V_e = 2\sqrt{\frac{G}{d}(M_1+M_2)}$$

(19) (d) Let m be the mass of the body. The gravitational potential energy of the body at the surface of the earth is

$$U = -\frac{GM_e m}{R_e}$$

The potential energy at a height 10 R_e above the surface of the earth will be

$$U' = -\frac{GM_e m}{(R_e + 10R_e)}$$

$\therefore$ Increase in potential energy

$$U' - U = -\frac{GM_e m}{11R_e} + \left(\frac{GM_e m}{R_e}\right) = \frac{10}{11}\frac{GM_e m}{R_e}$$

This increase will be obtained from the initial kinetic energy given to the body. Hence if the body be thrown with a v velocity then

$$\frac{1}{2}mv^2 = \frac{10}{11}\frac{GM_e m}{R_e} \Rightarrow v = \sqrt{\frac{20Gm_e}{11R_e}}$$

Substituting the given values, we get

$$v = \sqrt{\left(\frac{20 \times (6.67 \times 10^{-11}) \times (6 \times 10^{24})}{11 \times (6.4 \times 10^6)}\right)}$$

$= 1.07 \times 10^4$ m/s.

(20) (b) $F = \frac{Gm(M-m)}{r^2}$

For maximum force $\frac{dF}{dm} = 0$

$$\Rightarrow \frac{d}{dm}\left(\frac{GmM}{r^2} - \frac{Gm^2}{r^2}\right) = 0$$

$$\Rightarrow M - 2m = 0 \Rightarrow \frac{m}{M} = \frac{1}{2}$$

(21) (b) $g' = g - \omega^2 R\cos^2\lambda$

For weightlessness at equator $\lambda = 0$ and $g' = 0$

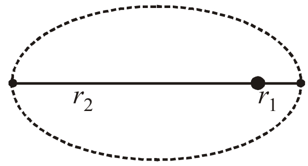
$$\therefore 0 = g - \omega^2 R \Rightarrow \omega = \sqrt{\frac{g}{R}} = \frac{1}{800}\frac{rad}{s}$$

(22) (a) k represents gravitational constant which depends only on the system of units.

(23) (a) All statements except (4) are wrong.

(24) (a) Value of g decreases when we go from poles to equator.

(25) (b)



Gravitational PE at perihelion $= -GMm/r_1$ as r_1 is minimum Therefore, PE is minimum.

(26) (c) Total energy = constant.

(27) (c) As Pluto moves away, displacement has component opposite to air force, hence work done is –negative.

(28) (b) For two electron $\frac{F_g}{F_e} = 10^{-43}$ i.e. gravitational force is negligible in comparison to electrostatic force of attraction.

(29) (c) The universal gravitational constant G is totally different from g.

$$G = \frac{FR^2}{Mm}$$

The constant G is scalar and posses the dimensions $\left[M^{-1}L^3T^{-2}\right]$.

$$g = \frac{GM}{R^2}$$

g is a vector and has got the dimensions $\left[M^0LT^{-2}\right]$.

It is not a universal constant.

(30) (a) As the rotation of earth takes place about polar axis therefore body placed at poles will not feel any centrifugal force and its weight or acceleration due to gravity remains unaffected.