
NDA-CDS 2 2024
GS
LIVE
PHYSICS
CLASS 9
NAVJYOTI SIR
SSBCrack EXAMS

10 July 2024 Live Classes Schedule

8:00AM	10 JULY 2024 DAILY CURRENT AFFAIRS	RUBY MA'AM
9:00AM	10 JULY 2024 DAILY DEFENCE UPDATES	DIVYANSHU SIR

SSB INTERVIEW LIVE CLASSES

9:00AM	OVERVIEW OF GTO	ANURADHA MA'AM

NDA 2 2024 LIVE CLASSES

1:00PM	GS - PHYSICS - CLASS 9	NAVJYOTI SIR
4:00PM	MATHS - LOGARITHMS	NAVJYOTI SIR
5:30PM	ENGLISH - USAGE OF PAIRED WORDS - CLASS 2	ANURADHA MA'AM

CDS 2 2024 LIVE CLASSES

1:00PM	GS - PHYSICS - CLASS 9	NAVJYOTI SIR
5:30PM	ENGLISH - USAGE OF PAIRED WORDS - CLASS 2	ANURADHA MA'AM

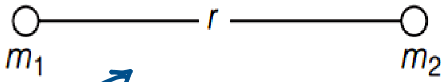
GRAVITATION AND FLUID MECHANICS

WHAT WILL WE STUDY ?

- Newton's Law of Gravitation
- Acceleration due to Gravity (g)
- Kepler's Laws
- Time period of a Pendulum
- Pressure and Pascal's Law ✓
- Density and Specific Gravity ✓
- Buoyancy and Archimedes Principle

NEWTON's LAW OF GRAVITATION

- Gravitational force is a attractive force between two masses m_1 and m_2 separated by a distance r .



Gravitational force, $F = \frac{Gm_1 m_2}{r^2}$

where, G is universal gravitational constant.

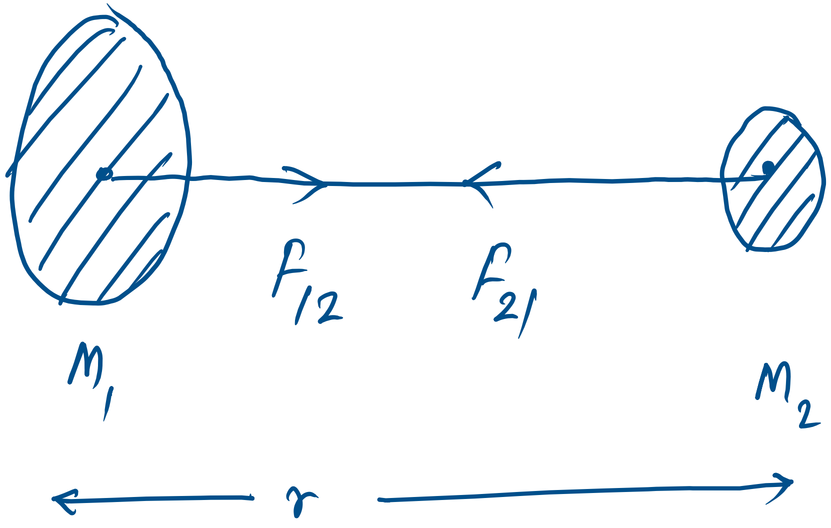
The value of G is 6.67×10^{-11} N-m^2 kg^{-2} and is same throughout the universe.

$$G = \frac{Fr^2}{m_1 m_2} \quad \Big| \quad \frac{Nm^2}{kg^2} \equiv Nm^2 kg^{-2}$$

GRAVITATIONAL FORCE

- Gravitational force is a central as well as conservative force.
- The law of gravitational is applicable for all bodies, irrespective of their size, shape and position.
- Gravitational force acting between sun and planet provide it centripetal force for orbital motion.
- Newton's third law of motion holds good for the force of gravitation. It means the gravitational forces between two bodies are action-reaction pairs.

centripetal force $= m_{planet} \times \frac{v^2}{r} = \frac{G M_{sun} m_{planet}}{r^2} \Rightarrow$



$|\vec{F_{12}}| = |\vec{F_{21}}|$ equal forces but different directions.

Gravitational force by body 1 on 2 $= \dfrac{G m_1 m_2}{r^2} = F$

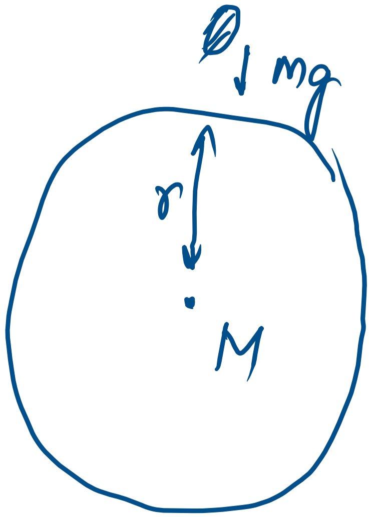
" " " 2 on 1 $= \dfrac{G m_2 m_1}{r^2} = F$

Acceleration Due to Gravity (g)

- The uniform acceleration produced in a freely falling object due to the gravitational pull of the earth is known as acceleration due to gravity.
- It is a vector quantity and its direction is towards the centre of the earth.
- The value of g is independent of the mass of the object which is falling freely under gravity.

Relation between g and G is given by, $g = \frac{GM}{R^2}$

$g \approx 9.8\ m/s^2$



Weight = Gravitational pull / Force

$mg = \frac{GMm}{r^2}$

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

Acceleration Due to Gravity (g)

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- The value of g changes slightly from place to place. (because of shape of earth, radius is not constant)
- The value of g is taken to be 9.8 m/ s^2 for all practical purposes.
- The value of acceleration due to gravity on the moon is about one sixth of that on the earth and on the sun is about 27 times of that on the earth.

Relation between g and G is given by, $g = \dfrac{GM}{R^2}$

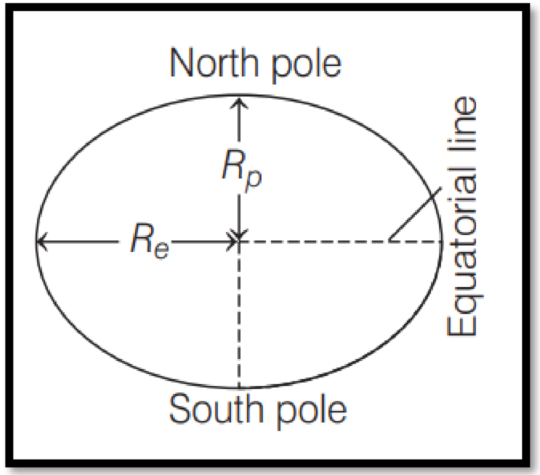
$$g_{moon} = \frac{1}{6}(g_{earth})$$

$$g_{sun} = 27(g_{earth})$$

FACTORS AFFECTING 'g'

1. SHAPE OF EARTH :

Acceleration due to gravity $g \propto \frac{1}{R^2}$.



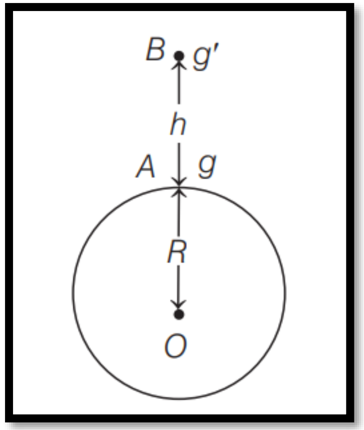
$g = \frac{GM}{r^2}$

- g is minimum at equator and maximum at poles.

FACTORS AFFECTING 'g'

2. ALTITUDE AND DEPTH:

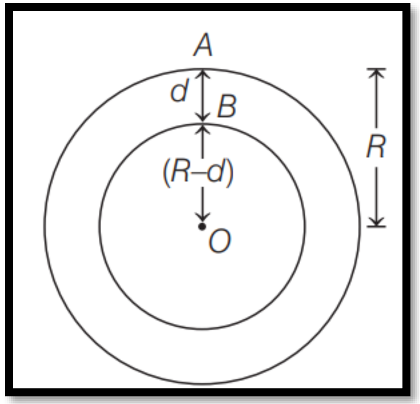
Acceleration due to earth's gravity is maximum on its surface decreasing whether you go up or down.



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

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

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



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

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

$$g - g\left(\frac{d}{R}\right)$$

KEPLER's LAWS

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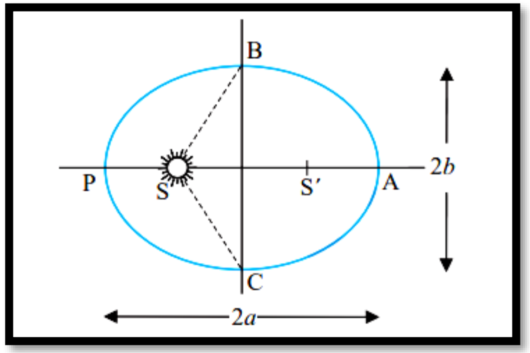
1. **Law of orbits :** All planets move in elliptical orbits with the Sun situated at one of the foci.

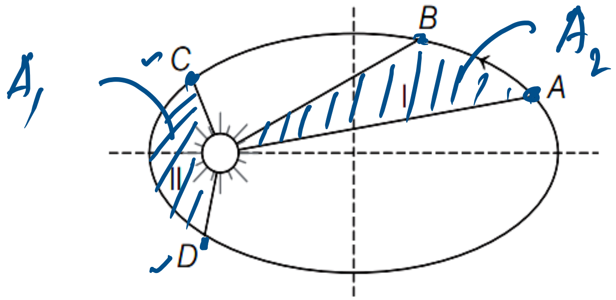
(Total – Two focus)



2. **Law of areas :** The line that joins any planet to the sun sweeps equal areas in equal intervals of time.

$$\frac{dA}{dt} = \text{constant} = \frac{L}{2m}$$

Areal velocity of a planet $\frac{dA}{dt} = \frac{\mathbf{L}}{2m}$ = constant



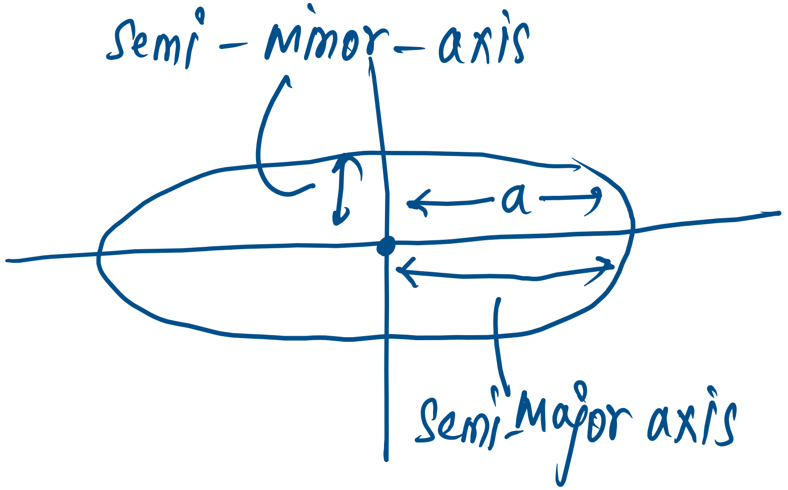
where, L = angular momentum and m = mass of the planet.

$A_1 = A_2$ (for same time intervals)

KEPLER's LAWS

3. <u>Law of period</u> : The square of the time period of revolution of a planet around the sun is directly proportional to the cube of semi-major axis of its elliptical orbit.

$$T^2 \propto a^3 \quad \text{or} \quad \left(\frac{T_1}{T_2}\right)^2 = \left(\frac{a_1}{a_2}\right)^3$$



For circular orbits,

$T^2 \propto R^3$ (R - radius of orbit)

TIME PERIOD OF A PENDULUM

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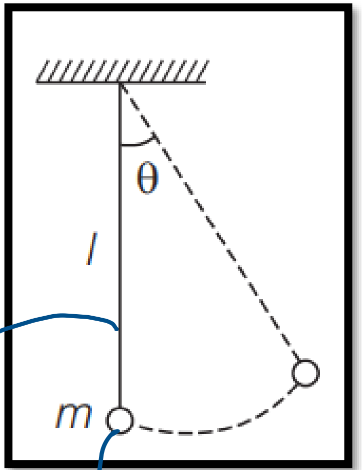
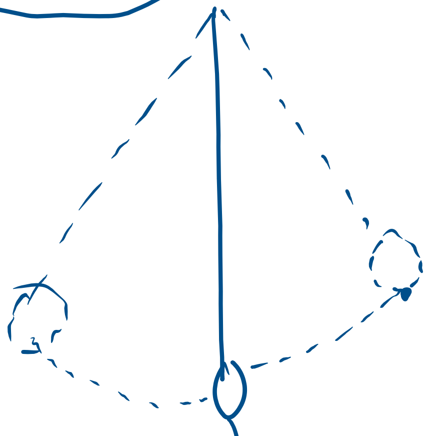
- **A simple pendulum consists of a heavy point mass suspended from a rigid support by means of an elastic inextensible string.**

$$T = 2\pi\sqrt{\frac{l}{g}}$$





Should not change length because of weight of bob.

String of negligible mass (very less w.r.t. bob)

bob

mean position

$$T = 2\pi\sqrt{\frac{l}{g}}$$

$$g = 9.8$$

$$\pi = 3.14$$

$$\sqrt{g} = \sqrt{9.8} \approx 3.14 \approx \pi \text{ (approximately)}$$

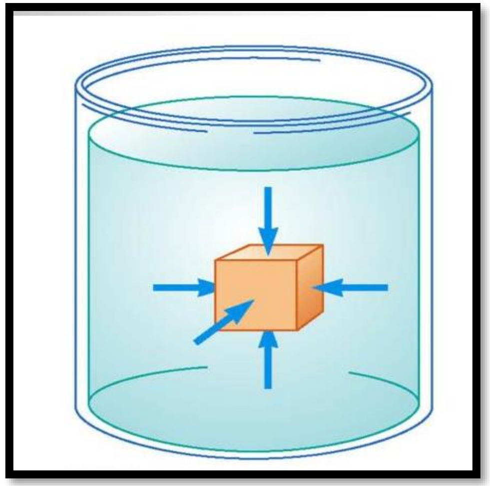
$$T \approx 2\sqrt{l}$$

Time period of pendulum, $T = \frac{2\pi\sqrt{l}}{\sqrt{g}} = 2\sqrt{l}$ (approxi.)

FLUIDS AND PRESSURE

- Fluids are those substances which can flow when an external force is applied on them. Liquids and gases are fluids.
- Pressure of liquid at a point is $p = \frac{\text{Thrust}}{\text{Area}} = \frac{F}{A}$.

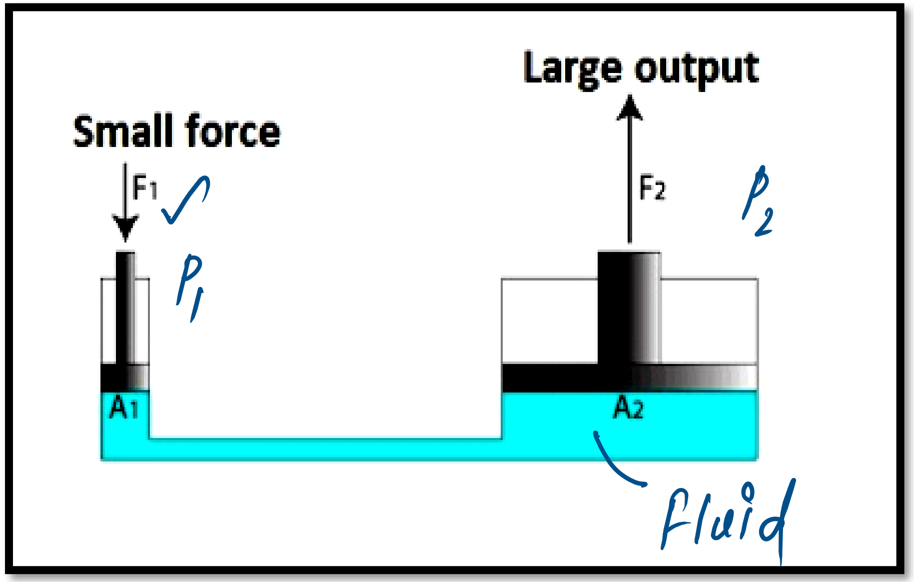
Thrust is The total normal force exerted by liquid at rest. (in perpendicular direction)



- Pressure is a scalar quantity. Its unit is Nm^{-2} or Pascal (Pa).

PASCAL 'S LAW

- The increase in pressure at a point in the enclosed liquid is transmitted equally in all directions in liquid and to the walls of the container.
- The working of hydraulic lift and hydraulic brakes are based on Pascal's law.



By Pascal's law,

$$P_1 = P_2$$

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

$$F_2 = \left(\frac{F_1}{A_1}\right)(A_2)$$

As A_2 is large, F_2 becomes large,

Atmospheric Pressure

- **The pressure exerted by the atmosphere on earth.**
- **At sea level, atmospheric pressure is equal to 76 cm of mercury column.**

Then, atmospheric pressure

$$= hdg = 76 \times 13.6 \times 980 \text{ dyne/cm}^2$$

$$= 0.76 \times 13.6 \times 10^3 \times 9.8 \text{ N/m}^2$$

$$1 \text{ atm} = 1.013 \times 10^5 \text{ Nm}^{-2} \text{ (or Pa)}$$

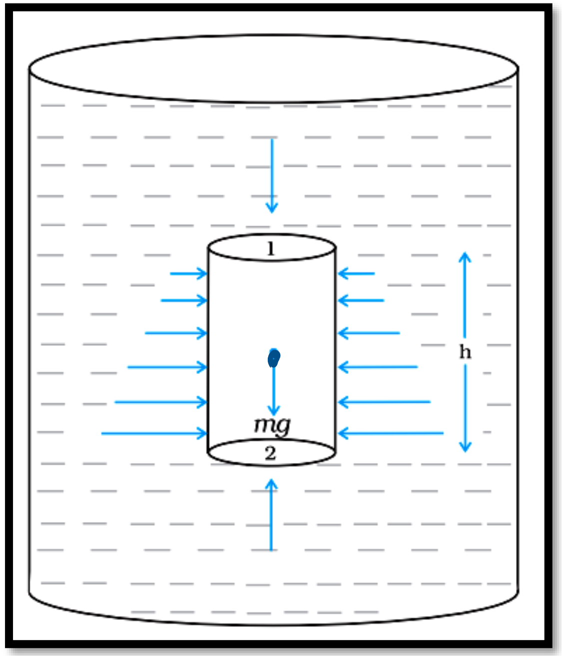
$h = 76$ cm

$\rho = 13.6 \text{ g cm}^{-3}$

$g = 980 \text{ cm}^2/\text{s}$

- **Aneroid barometer is used to measure atmospheric pressure.**

Variation of Pressure with Depth



$$p = h\rho g$$

$$P = P_a + \rho g h$$

atmospheric pressure

$$p = \frac{F}{A} = \frac{\text{weight}}{\text{Area}} = \frac{mg}{A} = \frac{(\rho V)g}{A}$$

$$p = \frac{\rho (A \times h) g}{A} = h\rho g$$

h — height of liquid column

ρ — density of fluid

g — accleration due to gravity

DENSITY AND SPECIFIC GRAVITY

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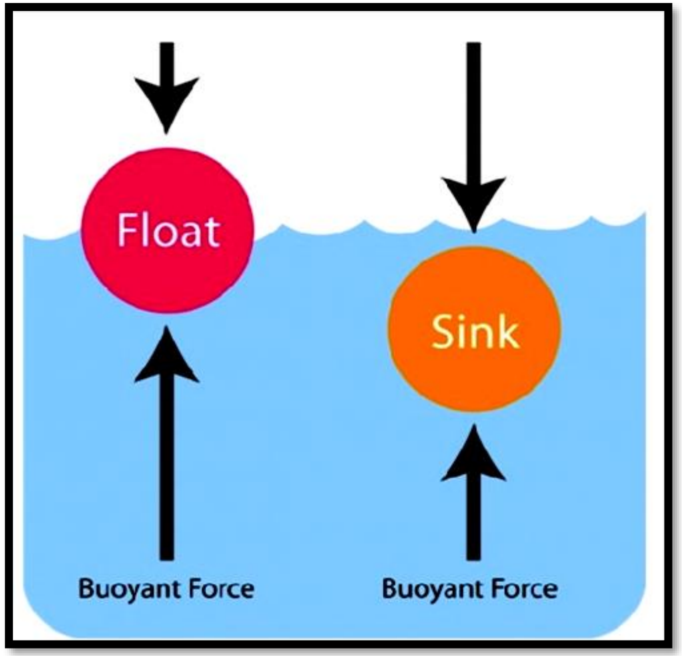
- For a fluid of mass m occupying volume V , density

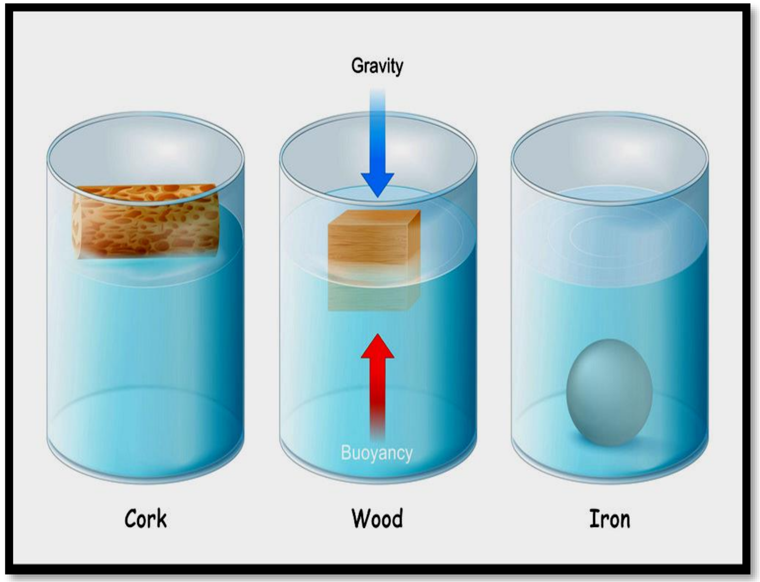
$$\rho = \frac{m}{V}$$

- Its SI unit is kg m^{-3}. It is a positive scalar quantity.
- A liquid is largely incompressible and its density is therefore, nearly constant at all pressures.
- The density of water at 4°C (277 K) is 1.0×10^3 kg m^{-3} / 1.0 g cm^{-3} (max. density)
- The relative density , or specific gravity of a substance is the ratio of its density to the density of water at 4°C. It has no units.

BUOYANCY

- **When a body is partially or fully immersed in a fluid, an upward force acts on it, which is called buoyant force, the phenomena is called buoyancy.**





$W > F_B \rightarrow$ sink

$W < F_B \rightarrow$ float

W – weight of body

F_B – buoyant force

ARCHIMEDES PRINCIPLE

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- **When a body is partially or fully immersed in a liquid, it loses some of its weight and it is equal to the weight of the liquid displaced by the immersed part of the body.**

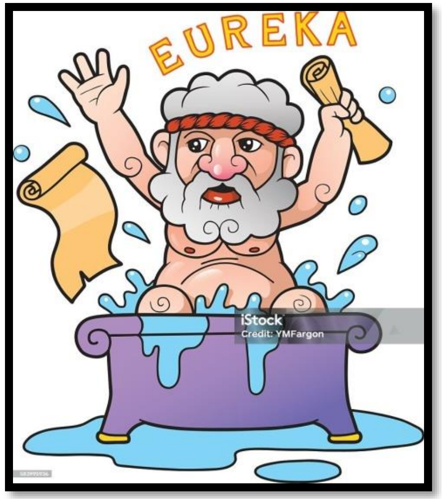
If T is the observed weight of a body of density σ when it is fully immersed in a liquid of density ρ, then real weight of the body

$$w = \frac{T}{\left(1 - \frac{\rho}{\sigma}\right)}$$

Reduced weight in fluid,

$$T = w\left(1 - \frac{\rho}{\sigma}\right)$$

$(T < w)$



SUMMARY

- **Newton's Law of Gravitation**
- **Acceleration due to Gravity**
- **Kepler's Laws**
- **Time period of a Pendulum**
- **Pressure and Pascal's Law**
- **Density and Specific Gravity**
- **Buoyancy and Archimedes Principle**

1. The SI unit of specific gravity is

A. gcm^{-3}

B. kgm^{-3}

C. No units

D. None of the Above

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2. An object is put one by one in three liquids having different densities. The object floats with $\frac{1}{9}$, $\frac{2}{11}$ and $\frac{3}{7}$ parts of their volumes outside the liquid surface in liquids of densities d_1, d_2 and d_3 respectively. Which of the following statement is correct?

(a) $d_1 > d_2 > d_3$

(b) $d_1 > d_2 < d_3$

(c) $d_1 < d_2 > d_3$

(d) $d_1 < d_2 < d_3$

2. An object is put one by one in three liquids having different densities. The object floats with $\frac{1}{9}$, $\frac{2}{11}$ and $\frac{3}{7}$ parts of their volumes outside the liquid surface in liquids of densities d_1, d_2 and d_3 respectively. Which of the following statement is correct?

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(d) $d_1 < d_2 < d_3$

Answer: (D)

3. The working of Hydraulic Breaks and Lifts is based on

A. Archimedes Principle

B. Law of Floatation

C. Bernoulli’s Principle

D. Pascal’s Law

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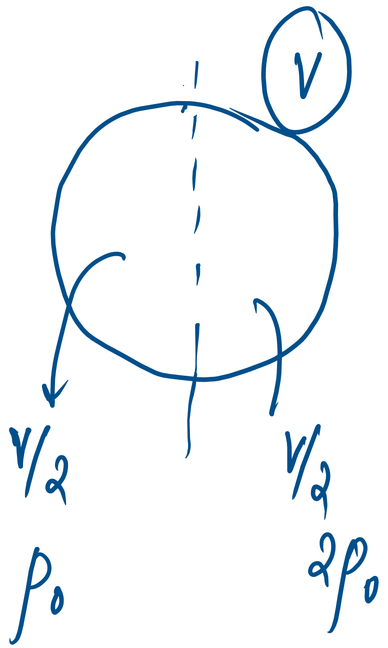
4. An object is made of two equal parts by volume; one part has density ρ_0 and the other part has density $2\rho_0$. What is the average density of the object?

(a) $3\rho_0$

(b) $\frac{3}{2}\rho_0$ ✓

(c) ρ_0

(d) $\frac{1}{2}\rho_0$



$$\text{avg. density} = \frac{\text{Total mass}}{\text{Total volume}} = \frac{\rho_0 \frac{V}{2} + 2\rho_0 \frac{V}{2}}{V}$$

$$= \frac{\frac{V}{2}(3\rho_0)}{V} = \left(\frac{3\rho_0}{2}\right)$$

4. An object is made of two equal parts by volume; one part has density ρ_0 and the other part has density $2\rho_0$. What is the average density of the object?

(a) $3\rho_0$

(b) $\frac{3}{2}\rho_0$

(c) ρ_0

(d) $\frac{1}{2}\rho_0$

Answer: (B)

5. If an object mass on the Moon surface is 40 kg then what will be the mass of the same object on the Earth's surface ?

A. 40 kg

B. 20 kg

C. 6.66 kg

D. 10 kg

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A. 40 kg

B. 20 kg

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D. 10 kg

6. The weight of an object at the centre of the earth of radius R is

A. Zero

B. Infinite

C. R times the weight at the surface of the Earth

D. $1/R^2$ times the weight at surface of Earth

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A. Zero

B. Infinite

C. R times the weight at the surface of the Earth

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7. Law Of Gravitation Gives The Gravitational Force Between

A. The Earth and a point Mass only

B. The Earth and Sun only

C. Any Two Bodies Having Some Mass

D. Two charged bodies only

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8. In the relation $F = GMm/d^2$, the quantity G is

A. Depends on the value of g at the place of observation

B. Is used only when the Earth is one of the two masses

C. Is greatest at the surface of Earth

D. Is universally constant

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A. Depends on the value of g at the place of observation

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9. The time period of a 1 m long pendulum approximates to

(a) 6 s

(b) 4 s

(c) 2 s

(d) 1 s

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(a) 6 s

(b) 4 s

(c) 2 s

(d) 1 s

Answer: (C)

10. All objects experience a buoyancy when they are immersed in a fluid. Buoyancy is

(a) a downward force

(b) a downward pressure

(c) an upward force

(d) an upward pressure

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(c) an upward force

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Answer: (C)

11. An apple falls from a tree because of gravitational attraction between the Earth and the Apple. If F1 is the magnitude of the Force exerted by the Earth on the apple and F2 is the magnitude of Force exerted by the Apple on the Earth , then

A. F1 > F2

B. F1 < F2

C. F1 = F2

D. Can’t say

11. An apple falls from a tree because of gravitational attraction between the Earth and the Apple. If F1 is the magnitude of the Force exerted by the Earth on the apple and F2 is the magnitude of Force exerted by the Apple on the Earth , then

A. F1 > F2

B. F1 < F2

C. F1 = F2

D. Can't say

12. Two planets orbit the Sun in circular orbits, with their radius of orbit as $R_1 = R$ and $R_2 = 4R$. Ratio of their periods (T_1/T_2) around the Sun will be

(a) 1/16

(b) 1/8

(c) 1/4

(d) 1/2

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(a) 1/16

(b) 1/8

(c) 1/4

(d) 1/2

Answer: (B)

13. A liquid is kept in a glass beaker. Which one of the following statements is correct regarding the pressure exerted by the liquid column at the base of the beaker ?

(a) The pressure depends on the area of the base of the beaker

(b) The pressure depends on the height of liquid column

(c) The pressure does not depend on the density of the liquid

(d) The pressure neither depends on the area of the base of the beaker nor on the height of liquid column

13. A liquid is kept in a glass beaker. Which one of the following statements is correct regarding the pressure exerted by the liquid column at the base of the beaker ?

(a) The pressure depends on the area of the base of the beaker

(b) The pressure depends on the height of liquid column

(c) The pressure does not depend on the density of the liquid

(d) The pressure neither depends on the area of the base of the beaker nor on the height of liquid column

Answer: (B)

14. A planet has a mass M_1 and radius R_1. The value of acceleration due to gravity on its surface is g_1. There is another planet 2, whose mass and radius both are two times that of the first planet. Which one of the following is the acceleration due to gravity on the surface of planet 2?

(a) g_1

(b) $2g_1$

(c) $g_1/2$

(d) $g_1/4$

14. A planet has a mass M_1 and radius R_1. The value of acceleration due to gravity on its surface is g_1. There is another planet 2, whose mass and radius both are two times that of the first planet. Which one of the following is the acceleration due to gravity on the surface of planet 2?

(a) g_1

(b) $2g_1$

(c) $g_1/2$

(d) $g_1/4$

Answer: (C)

15. Whether an object will float or sink in a liquid, depends on

(a) mass of the object only

(b) mass of the object and density of liquid only

(c) difference in the densities of the object and liquid

(d) mass and shape of the object only

15. Whether an object will float or sink in a liquid, depends on

(a) mass of the object only

(b) mass of the object and density of liquid only

(c) difference in the densities of the object and liquid

(d) mass and shape of the object only

Answer: (C)

16. Which one of the following statements about gravitational force is NOT correct ?

(a) It is experienced by all bodies in the universe

(b) It is a dominant force between celestial bodies

(c) It is a negligible force for atoms

(d) It is same for all pairs of bodies in our universe

16. Which one of the following statements about gravitational force is NOT correct ?

(a) It is experienced by all bodies in the universe

(b) It is a dominant force between celestial bodies

(c) It is a negligible force for atoms

(d) It is same for all pairs of bodies in our universe

Answer: (D)

17. Suppose there are two planets, 1 and 2, having the same density but their radii are R_1 and R_2 respectively, where $R_1 > R_2$. The accelerations due to gravity on the surface of these planets are related as

(a) $g_1 > g_2$

(b) $g_1 < g_2$

(c) $g_1 = g_2$

(d) Can't say anything

17. Suppose there are two planets, 1 and 2, having the same density but their radii are R_1 and R_2 respectively, where $R_1 > R_2$. The accelerations due to gravity on the surface of these planets are related as

(a) $g_1 > g_2$

(b) $g_1 < g_2$

(c) $g_1 = g_2$

(d) Can't say anything

Answer: (B)

18. The Force Of Attraction Between Two Unit Point Masses Separated By A Unit Distance Is Called

A. Gravitational Potential

B. Acceleration Due To Gravity

C. Gravitational Field

D. Universal Gravitational Constant

18. The Force Of Attraction Between Two Unit Point Masses Separated By A Unit Distance Is Called

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B. Acceleration Due To Gravity

C. Gravitational Field

D. Universal Gravitational Constant

19. Two bodies of mass M each are placed R distance apart. In another system, two bodies of mass 2M each are placed $\frac{R}{2}$ distance apart. If F be the gravitational force between the bodies in the first system, then the gravitational force between the bodies in the second system will be

(a) 16 F ✓

(b) 1 F

(c) 4 F

(d) None of the above

$$F = \frac{GMM}{R^2} = \frac{GM^2}{R^2}$$

$$F'_{(\text{new system})} = \frac{G(2M)(2M)}{\left(\frac{R}{2}\right)^2}$$

$$= \frac{16\,GM^2}{R^2} = 16F$$

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(a) 16 F

(b) 1 F

(c) 4 F

(d) None of the above

Answer: (A)

20. A pendulum clock is lifted to a height where the gravitational acceleration has a certain value g. Another pendulum clock of same length but of double the mass of the bob is lifted to another height where the gravitational acceleration is g/2. The time period of the second pendulum would be :

(in terms of period T of the first pendulum)

(a) $\sqrt{2}\,T$ ✓

(b) $\frac{1}{\sqrt{2}}T$

(c) $2\sqrt{2}\,T$

(d) T

$T_{first} = 2\pi\sqrt{\frac{l}{g}} = T$

$T_{second} = 2\pi\sqrt{\frac{l}{g/2}} = 2\pi\sqrt{\frac{2l}{g}}$

$= 2\pi\sqrt{2}\sqrt{\frac{l}{g}}$

$= 2\sqrt{2}\,\pi\sqrt{\frac{l}{g}}$

$= \sqrt{2}\left(2\pi\sqrt{\frac{l}{g}}\right)$

$= \sqrt{2}\,T$

{T of pendulum is not dependent on mass of bob}

20. A pendulum clock is lifted to a height where the gravitational acceleration has a certain value g. Another pendulum clock of same length but of double the mass of the bob is lifted to another height where the gravitational acceleration is g/2. The time period of the second pendulum would be :

(in terms of period T of the first pendulum)

(a) $\sqrt{2}\,T$

(b) $\frac{1}{\sqrt{2}}\,T$

(c) $2\sqrt{2}\,T$

(d) T

Answer: (A)