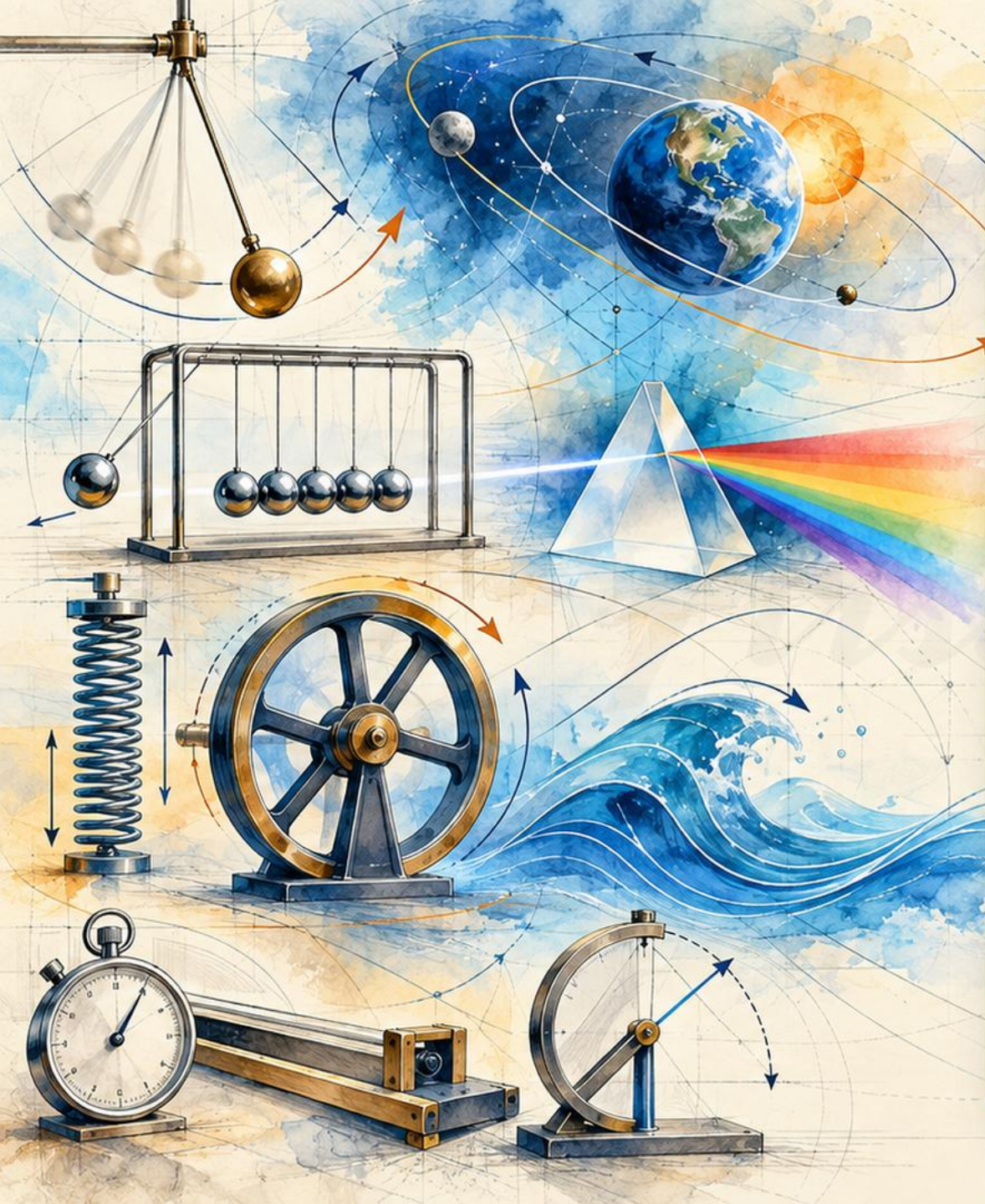




PHYSICS • CLASS 11

7

CHAPTER

Gravitation

NCERT SOLUTIONS

EXERCISE SOLUTION: QUESTION 7.1

- (a) A hollow conductor can shield electric forces. Can a hollow sphere, or another shield, block the gravitational influence of nearby matter?

Answer: No. A uniform spherical shell produces zero field inside due to its own mass, but it does not block gravity from external matter. There is no analogous gravitational shield.

- (b) An astronaut cannot detect uniform gravity inside a small freely orbiting spacecraft. Can gravity be detected inside a very large orbiting station?

Answer: Yes, through tidal effects. Earth's field differs slightly from one part of a large station to another. Freely moving objects then have different accelerations, revealing the variation of gravity.

- (c) The Sun pulls Earth more strongly than the Moon does. Why are the Moon's tides stronger?

Answer: Tides depend on the difference in gravitational pull across Earth, not simply the total force on Earth. The much closer Moon produces a larger variation across Earth.

$$\text{Gravitational force} \propto \frac{M}{r^2}$$

$$\text{Tidal effect} \propto \frac{M}{r^3}$$

EXERCISE SOLUTION: QUESTION 7.2

Choose the correct alternatives and explain.

- (a) Does acceleration due to gravity increase or decrease with altitude?

Answer: Decreases.

Greater distance from Earth's centre means a weaker field.

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

- (c) Is gravity independent of Earth's mass or the falling body's mass?

Answer: Mass of the body.

$$F = \frac{GMm}{r^2} \Rightarrow g = \frac{F}{m} = \frac{GM}{r^2}$$

Thus, the acceleration due to gravity does not depend on the mass of the falling body.

- (b) Does it increase or decrease with depth in a uniform-density Earth?

Answer: Decreases.

Only the mass within the smaller radius contributes to the field there.

$$g(d) = g_0 \left(1 - \frac{d}{R}\right)$$

- (d) Is $-GMm \left(\frac{1}{r_2} - \frac{1}{r_1}\right)$ more or less accurate than $mg(r_2 - r_1)$ for a potential-energy change?

Answer: More accurate.

The inverse-distance expression accounts for changing gravity. The constant-gravity formula is a near-surface approximation for a small height change.

$$\Delta U = -GMm \left(\frac{1}{r_2} - \frac{1}{r_1}\right).$$

EXERCISE SOLUTION: QUESTION 7.3

Suppose a planet goes around the Sun twice as fast as Earth. What is its orbital size compared with Earth's orbit?

Answer:: Interpret 'twice as fast' as twice the orbital frequency, so the period is halved.

$$T_P = \frac{T_E}{2}$$

Kepler's third law relates orbital period to the semi-major axis.

$$T^2 \propto a^3$$
$$\left(\frac{T_P}{T_E}\right)^2 = \left(\frac{a_P}{a_E}\right)^3$$

Hence, the ratio of orbital sizes is

$$\frac{a_P}{a_E} = \left(\frac{T_P}{T_E}\right)^{2/3} = \left(\frac{1}{2}\right)^{2/3} = 2^{-2/3}$$

$$\frac{a_P}{a_E} \approx 0.630$$

The faster-revolving planet has the smaller orbit. For circular orbits, the semi-major axis is simply the orbital radius.

Orbital size ≈ 0.63 times Earth's orbital size.

EXERCISE SOLUTION: QUESTION 7.4

Q. 7.4 Io orbits Jupiter in 1.769 days at an orbital radius of 4.22×10^8 m. Show that Jupiter's mass is about one-thousandth of the Sun's mass. Use $G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$ and $M_{\text{Sun}} \approx 2.0 \times 10^{30} \text{ kg}$.

Solution:

Treat Io's orbit as circular and neglect Io's mass compared with Jupiter. Gravity supplies the centripetal force.

$$G \frac{M_J m}{r^2} = m \frac{4\pi^2 r}{T^2}$$

$$M_J = \frac{4\pi^2 r^3}{GT^2}$$

$$T = 1.769 \times 86400 = 152841.6 \text{ s.}$$

$$\begin{aligned} M_J &= \frac{4\pi^2 (4.22 \times 10^8)^3}{(6.67 \times 10^{-11}) (152841.6)^2} \\ &\approx 1.90 \times 10^{27} \text{ kg.} \end{aligned}$$

$$\begin{aligned} \frac{M_J}{M_{\text{Sun}}} &= \frac{1.90 \times 10^{27}}{2.0 \times 10^{30}} \\ &= 9.5 \times 10^{-4} \approx \frac{1}{1000}. \end{aligned}$$

Jupiter has about one-thousandth of the Sun's mass.



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