Gravitation
NCERT Examples

1. **Page 134 - Example 10.1:**
   The mass of the earth is 6×10^{24} *kg* and that of the moon is 7.4×10^{22} *kg*. If the distance between the earth and the moon is 3.84×10^{5} *km*, calculate the force exerted by the earth on the moon. (Take $G = 6.67 \times 10^{-11}\ N\ m^2\ kg^{-2}$)

2. **Page 136 - Example 10.2:**
   A car falls off a ledge and drops to the ground in 0.5 *s*. Let $g = 10\ m\ s^{-2}$ (for simplifying the calculations).

   (i) What is its speed on striking the ground?

   (ii) What is its average speed during the 0.5 *s*?

   (iii) How high is the ledge from the ground?

3. **Page 136 - Example 10.3:**
   An object is thrown vertically upwards and rises to a height of 10 *m*. Calculate (i) the velocity with which the object was thrown upwards and (ii) the time taken by the object to reach the highest point.

4. **Page 138 - Example 10.4:**
   Mass of an object is 10 *kg*. What is its weight on the earth?

5. **Page 138 - Example 10.5:**
   An object weighs 10 *N* when measured on the surface of the earth. What would be its weight when measured on the surface of the moon?

6. **Page 139 - Example 10.6:**
   A block of wood is kept on a tabletop. The mass of wooden block is 5 *kg* and its dimensions are 40 *cm* $\times$ 20 *cm* $\times$ 10 *cm*. Find the pressure exerted by the wooden block on the table top if it is made to lie on the table top with its sides of dimensions (a) 20 *cm* $\times$ 10 *cm* and (b) 40 *cm* $\times$ 20 *cm*.

7. **Page 142 - Example 10.7:**
   Relative density of silver is 10.8. The density of water is $10^3\ kg\ m^{-3}$. What is the density of silver in SI unit?

Answers

1. The mass of the earth, $M = 6 \times 10^{24}\ kg$,
   The mass of moon, $m = 7.4 \times 10^{22}\ kg$,
   The distance between the earth and the moon,

$$\begin{aligned} d &= 3.84 \times 10^{5}\ km \\ &= 3.84 \times 10^{5} 1000\ m \\ &= 3.84 \times 10^{8}\ m \\ G &= 6.7 \times 10^{-11}\ N\, m^2\, kg^{-2} \end{aligned}$$

   From Eq. (4), the force exerted by the earth on the moon is,

$$\begin{aligned} F &= G\frac{Mm}{d^2} \\ &= \frac{(6.710^{-11} N\, m^2\, kg^{-2}) \times (6 \times 10^{24}\ kg) \times (7.4 \times 10^{22}\ \ kg)}{(3.8410^{8}\ \ m)^2} \\ &= 2.0210^{20}\ \ N \end{aligned}$$

   Thus, the force exerted by the earth on the moon is $2.02 \times 10^{20}\ N$.

2. Time taken, $t = \frac{1}{2}\ s$
   Initial velocity, $u = 0\ m\ s^{-1}$,
   As acceleration due to gravity is acting along to the direction of motion.
   Hence, $g = 10\ m\ s^{-2}$.
   Acceleration of the car, $a = +10\ m\ s^{-2}$ (downward)

   (i) speed,

$$\begin{aligned} v &= at \\ &= 10\ m\ s^{-2} \times 0.5\ s \\ &= 5\ m\ s^{-1} \end{aligned}$$

   (ii) average speed,

$$\begin{aligned} &= \frac{u + v}{2} \\ &= \frac{(0\ m\ s^{-1} + 5\ m\ s^{-1})}{2} \\ &= 2.5\ m\ s^{-1} \end{aligned}$$

(iii) distance travelled,

$$\begin{aligned} s &= \frac{1}{2} a\, t^2 \\ &= \frac{1}{2} \times 10\ m\ s^{-2} \times (0.5\ s)^2 \\ &= \frac{1}{2} \times 10\ m\ s^{-2} \times 0.25\ s \\ &= 1.25\ m \end{aligned}$$

Thus,

(i) its speed on striking the ground, = $5\ m\ s^{-1}$

(ii) its average speed during the $0.5\ s$ = $2.5\ m\ s^{-1}$

(iii) height of the ledge from the ground, = $1.25\ m$

3. Distance travelled, $s = 10\ m$
Final velocity, $v = 0\ m\ s^{-1}$,
Acceleration due to gravity, $g = 9.8\ m\ s^{-2}$.
Acceleration of the object, $a = -9.8\ m\ s^{-2}$ (upward motion)

(i)

$$\begin{aligned} v^2 &= u^2 + 2\, a\, s \\ 0 &= u^2 + 2 \times (-9.8\ m\ s^{-2}) \times 10\ m \\ -u^2 &= -2 \times 9.8 \times 10\ m^2\ s^{-2} \\ u &= \sqrt{196}\ m\ s^{-1} \\ u &= 14\ m\ s^{-1} \end{aligned}$$

(ii)

$$\begin{aligned} v &= u + a\, t \\ 0 &= 14\ m\ s^{-1} u^2 - 9.8\ m\ s^{-2} \times t \\ -u^2 &= -2 \times 9.8 \times 10\ m^2\ s^{-2} \\ t &= 1.43\ s \end{aligned}$$

Thus,

(i) initial velocity, $u = 14\ m\ s^{-1}$

(ii) Time taken, $t = 1.43\ s$

4. Mass, $m = 10\ kg$,
   Acceleration due to gravity, $g = 9.8\ m\ s^{-2}$.

   We know that,

$$\begin{aligned} W &= m \times g \\ &= 10 \times 9.8 \\ &= 98\ N \end{aligned}$$

   Thus, the weight of the object is 98 N.

5. We know, Weight of object on the moon = (1/6) × its weight on the earth.
   That is,

$$\begin{aligned} W_m &= \frac{W_e}{6} = \frac{10}{6}\ N \\ &= 1.67\ N \end{aligned}$$

   Thus, the weight of object on the surface of the moon would be 1.67 N.

6. The mass of the wooden block = 5 kg
   The dimensions = 40 cm × 20 cm × 10 cm
   Here, the weight of the wooden block applies a thrust on the table top. That is,

$$\begin{aligned} \textit{Thrust} = F &= m \times g \\ &= 5\ kg \times 9.8\ m\ s^{-2} \\ &= 49\ N \\ \text{Area of a side} &= \text{length} \times \text{breadth} \\ &= 20\ cm \times 10\ cm \\ &= 200\ cm^2 = 0.02\ m^2 \\ \text{Pressure} &= \frac{49\ N}{0.02\ m^2} \\ &= 2450\ N\ m^{-2} \end{aligned}$$

When the block lies on its side of dimensions 40 $cm \times 20\ cm$, it exerts the same thrust.

$$\begin{aligned} \text{Area} &= \text{length} \times \text{breadth} \\ &= 40\ cm \times 20\ cm \\ &= 800\ cm^2 = 0.08\ m^2 \\ \text{Pressure} &= \frac{49\ N}{0.08\ m^2} \\ &= 612.5\ N\ m^{-2} \end{aligned}$$

The pressure exerted by the side 20 $cm \times 10\ cm$ is 2450 $N\ m^{-2}$ and by the side 40 $cm \times 20\ cm$ is 612.5 $N\ m^{-2}$.

7. Relative density of silver = 10.8

We know that,

$$\begin{aligned} \text{Relative Density} &= \frac{\text{Density of silver}}{\text{Density of water}} \\ \text{Density of silver} &= \text{Relative Density} \times \text{Density of water} \\ &= 10.8 \times 10^3\ kg\ m^{-3} \end{aligned}$$