CUBE NOTES

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# Kinematics: Acceleration due to gravity

*Key Idea*

- Acceleration due to gravity is $9.8m/s^2$. If you write it as $(9.8m/s)/s$, it can be interpreted as: velocity of the object increases by $9.8\ m/s$ every second
- Hence, the displacement of the object also increases every second
- Gravity $g$ is a vector, always pointing downwards.
  - The magnitude is written as $9.8\ m/s$ .
  - To indicate the direction, write it as $-9.8\ m/s$
- Use the negative sign when working with equations to indicate its direction

## Equations and formulas

| Formula/ Equation | Description | Note |
|---|---|---|
| $g = 9.8\ \mathrm{m/s^2}$ | Acceleration due to gravity | Always taken as -ve when used in equations |
| $g = 9.8(\mathrm{m/s})/\mathrm{s}$ | Velocity of the object increases by 9.8 m/s every second | Gives an understanding of how gravity affects motion |
| $v = 0$ | Velocity at max height | Acceleration is still equal to the value of g in downward direction |
| $\mathrm{s} = \frac{1}{2}gt^2$ | Displacement of a body *dropped* from a height in t seconds | - The word "dropped" always means zero initial velocity<br>- The displacement has no dependence on the height from which the object has been dropped |
| $h = H - \frac{1}{2}gt^2$ | Height of the body (h) *above the ground* after t seconds, when dropped from a height H | $\mathrm{s} = \frac{1}{2}gt^2$ in the above row has been subtracted from H |

| | | |
|---|---|---|
| $h_n - h_{n-1} = \frac{1}{2}g(2n-1)$ | Displacement *in the nth* second | |
| $t = \frac{v_0}{g}$ | Time to reach max height for an object projected upwards, with initial velocity vo | At max. height, v = 0 |
| $t = \sqrt{\frac{2h}{g}}$ or $t = v_o/g$ | Time to reach max height h if h is known. | Same would be the time taken to drop through height h. |
| $v_f = -v_i$ | If $v_f$ is the velocity at which the object hits the ground then it is same in magnitude as $v_i$ but opposite in direction. | Hence the negative sign |

## Tips and Tricks

1. Velocity and displacement vectors have positive/negative signs based on direction of motion
2. If object is falling down-
    a. The velocity vector is negative
    b. The displacement vector is also negative
3. If the object is moving up-
    a. The velocity vector is positive
    b. The displacement vector is also positive
4. In both the situations above, "g" will always be negative
5. At maximum height velocity becomes zero.
    a. However, the acceleration continues to be $9.8\frac{m}{s^2}$ acting in the downward direction.
    b. Remember, the force of gravity is present at all times, even when the velocity becomes zero.
6. If an object is moving vertically up *in a* balloon or rocket etc., then the object will have the same velocity as the vertical component of the velocity of the object carrying it up.
7. Displacement of a body dropped from a height = $1/2gt^2$
    a. That is displacement is proportional to $t^2$. Therefore, the distance covered in 1s, 2s, 3s etc. is in the ratio $1^2, 2^2, 3^2$
8. Displacement in the nth second is
9. $h_n - h_{n-1} = \frac{1}{2}g(2n-1)$
10. Hence the displacement of the object in 1st s, 2nd s, 3rd s are in the ratio 1:3:5 that is odd integers only

11. Always establish the origin or the point from where you will do all measurements
12. Do not mix distance and displacement.