AVIRAL
JEE | NEET | FOUNDATIONS

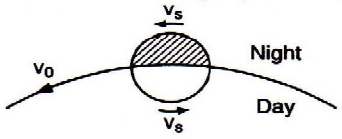
JEE ADV - PHYSICS
DPP -01

21 JAN 2020

TOPICS : KINEMATICS

1. The horizontal and vertical distances covered by a projectile at time t are given by $x = at$ and $y = bt^2 + ct$, where a, b and c are constants. What is the magnitude of the velocity of the projectile 1 second after it is fired?
[Ans. $\sqrt{a^2 + (2b+c)^2}$]

2. Taking the rotation and revolution of the earth into account, does a tree move faster during day or during night?



3. If a ball A is dropped while B is projected vertically down, which ball will reach the ground (a) first (b) with greater velocity?
[Ans. (a) B, (b) B]

4. A man can throw a stone R m away:
(a) What is the maximum height to which the stone will rise?
(b) How high can the person throw the stone?
[Ans. (a) $H = R/4$, (b) $H = R/2$]

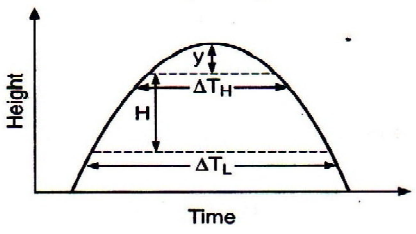
5. Two bodies P and Q are projected with velocities $\sqrt{2}\,u$ and u respectively. They cover the same horizontal distance. If body P is projected at 15° will the horizontal, then calculate the angle of projection of body Q.
[Ans. 45°]

6. Prove that :
The path of a projectile as seen from another projectile is a straight line.

7. Prove that for a projectile fired from level ground at an angle θ above the horizontal, the ratio of the maximum height H to the range R is given by
$$\frac{H}{R} = \frac{1}{4}\tan\theta$$

8. When a particle is projected at an angle to the horizontal, it has range R and time of flight t_1. If the same projectile is projected with same speed at another angle to have the same range, time of flight is t_2. Show that:
$$t_1 t_2 = (2R / g)$$

9. In an experiment for measuring 'g', a body is thrown vertically up in an evacuated tube and allowed to come back. If ΔT_L is the time interval between the two passages of the object across a lower level and ΔT_H the time interval between two passages across an upper level and H the distance between two levels as shown in Fig. 5.70, show that:
$$g = \frac{8H}{\Delta T_L^2 - \Delta T_H^2}$$



10. A bomb is dropped on an enemy post by an aeroplane flying with a horizontal velocity of 60 km/hr and at a height of 490 m. How far the aeroplane must be from the enemy post at the time of dropping the bomb, so that it may directly hit the target? ($g = 9.8\,m/s^2$)
[Ans. 500/3 m]

11. A fireman 50 m away from a burning building directs a stream of water from a firehouse at an angle of 30° above the horizontal. If the velocity of the stream is 40 m/s, at what height will the stream of water strike the building? ($g = 9.8\,m/s^2$)
[Ans. 18.65 m]

12. An astronaut on a strange planet finds that he can jump a maximum horizontal distance of 30 m if his initial speed is 9 m/s. (a) What is the acceleration of gravity on the planet? (b) What is the maximum height to which he can jump if he starts with the same initial speed?
[Ans. (a) $2.7\,m/s^2$, (b) 15 m]

13. A particle of mass 3 kg takes 2 s to move from A to B under the action of gravity and a constant force $\vec{F} \equiv 12\,\vec{i} - 3\,\vec{j} + 21\,\vec{k}$, where the unit vector $\vec{k}$ is in the direction of the upward vertical. The position vector of B is $15\,\vec{i} + 7\,\vec{j} - 6\,\vec{k}$ and the particle arrives at B with a velocity of $12\,\vec{i} + \vec{j} - 4\,\vec{k}$. Find the position vector of A and the velocity with which the particle leaves A.
[Ans. $\vec{r}_1 = -\vec{i} + 3\,\vec{j} - 4\,\vec{k}$]

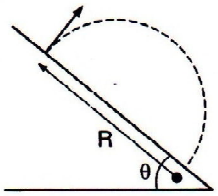
14. An aeroplane is observed by two persons travelling at 60 km/hour in two vehicles moving in opposite directions on a straight road. To an observer in one vehicle the plane appears to cross the road track at right angles while to the observer in the other vehicle the angle appears to be 45°. At what angle does the plane actually cross the road track and what is its speed relative to the ground?
[Ans. $\theta = \tan^{-1} 2$; $v = 134.16$ km/hour]

15. A motor boat set out at 11 a.m. from a position $-6\,\vec{i} - 2\,\vec{j}$ relative to a marker buoy and travels at a steady speed of magnitude $\sqrt{53}$ on a direct course to intercept a ship. The ship maintains a steady velocity vector $3\,\vec{i} + 4\,\vec{j}$ and at 12 noon is at a position $3\,\vec{i} - \vec{j}$ from the buoy. Find (a) the velocity vector of the motor boat, (b) the time of interception and (c) the position vector of point of interception from the buoy if distances are measured in kilometres and speeds in kilometre per hour.
[Ans. (a) $7\,\vec{i} + 2\,\vec{j}$; (b) 12.30 p.m. ; (c) $\frac{9}{2}\vec{i} + \vec{j}$]

16. A man can row a boat at 4.0 km/hr in still water. A river flows at 2.0 km/hr. (a) If he is crossing the river, in what direction the boat should go to reach a point directly opposite to his starting point? (b) If the river is 4.0 km wide how long will it take him to cross the river? (c) How long will it take him to row 2.0 km down the river and then back to his starting point? (d) How long will it take him to row 2.0 km up the river and then back to his starting point? (e) In what direction the boat should go, if he wants to cross the river in the smallest possible time ?

[**Ans.** (a) 30° to vertical; (b) $2/\sqrt{3}$ hr; (c) 4/3 hr; (d) 4/3 hr; (e) perpendicular to shore]

17. A projectile is launched with a velocity u at right angles to the slope, which is inclined at an angle θ with the horizontal. Derive an expression for the distance R to the point of impact.



[**Ans.** $R = \dfrac{2u^2}{g} \tan\theta \sec\theta$]

18. A shell is fired vertically from a cannon which is travelling at constant speed u = 30 km/hr. The projectile leaves the cannon with a velocity v_r = 20 m/s relative to the cannon. Show that the shell will land on the vehicle at the gun location and calculate the distance s travelled by the vehicle during the flight of shell.

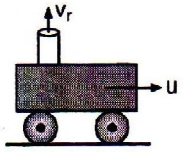


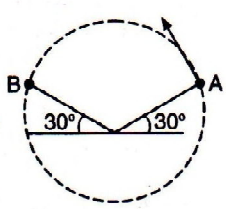
Fig. 5.72

[**Ans.** s = 34 m]

19. At a certain instant two cars are each 10 km from the intersection of roads that are perpendicular. Car A is moving east at 30 km/hr while car B moves north at 50 km/hr both toward the intersection. (a) Find their closest distance of approach. (b) Where are A and B when they are closest?

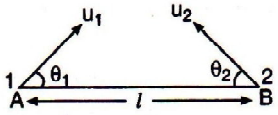
[**Ans.** (a) 3.42 km, (b) A: 2.95 km W, B: 1.75 km N.]

20. A stone at the end of a string is whirled in a vertical circle of radius r = 1.20 m at a constant speed u = 1.50 m/s. The centre of the string is 1.50 m above the ground. What is the range of the stone if it is released when the string is inclined at 30° with the horizontal: (a) at A (b) at B? What is the acceleration of the stone: (c) just before release at A (d) just after release at A?



[**Ans.**(a) 600 m; (b) 0.402 m; (c) 1.87 m/s^2 towards centre; (d) 9.80 m/s^2 down]

21. Two particles are projected simultaneously from points A and B respectively and they move in same plane. Find :



(a) the separation when they are closest to each other.
(b) the time elapsed to come closest to each other.
(c) condition that they collide in air.
(d) initial velocity of approach between the particles.
(e) initial angular velocity of first particle w.r.t. second particle.