Projectile Motion Worksheet: Show Your Work

1. Define projectile motion. Provide an example from everyday life.

2. List the key assumptions made in analyzing projectile motion problems.

3. Derive the equations of motion for the horizontal and vertical components of a projectile.

4. Explain the significance of the angle of projection in determining the trajectory of a projectile.

5. A ball is thrown with an initial velocity of 20 m/s at an angle of 30 to the horizontal. Calculate:
   (a) The horizontal and vertical components of the velocity.
   (b) The maximum height reached by the ball.

6. Derive the formula for the range of a projectile launched at an angle θ with an initial velocity v_0.

7. A stone is projected horizontally from a height of 45 m with an initial velocity of 15 m/s. Calculate:
   (a) The time it takes to hit the ground.
   (b) The horizontal distance covered.

8. A projectile is launched from an inclined plane with an initial velocity of 25 m/s at an angle of 40 above the plane. Solve for the time of flight.

9. Discuss how air resistance qualitatively affects the trajectory of a projectile.

10. A cannon fires a shell with an initial velocity of 50 m/s at an angle of 60 to the horizontal. Determine:
    (a) The time of flight.
    (b) The maximum height.
    (c) The range of the projectile.

11. A soccer ball is kicked at a velocity of 25 m/s at an angle of 45Ṡolve for the following:
    (a) The horizontal distance covered.
    (b) The time it remains in the air.
    (c) The velocity of the ball just before it hits the ground.

Solutions

1. Projectile motion is the motion of an object thrown or projected into the air, subject to only the acceleration of gravity. Example: A football kicked during a game.

2. Key assumptions:
   (a) Neglect air resistance.
   (b) Acceleration due to gravity is constant.
   (c) The only force acting is gravity.

3. Derivation:
   (a) Horizontal motion: $x = v_x t$.
   (b) Vertical motion: $y = v_y t - \frac{1}{2} g t^2$.

4. The angle of projection determines the range and maximum height of the projectile. An angle of 45 typically gives the maximum range under ideal conditions.

5. For the ball thrown at 20 m/s at 30:
   (a) $v_x = v_0 \cos\theta = 20 \cos 30 \approx 17.32\,\text{m/s}$.
   (b) $v_y = v_0 \sin\theta = 20 \sin 30 \approx 10\,\text{m/s}$.
   (c) Maximum height: $h = \frac{v_y^2}{2g} = \frac{10^2}{2 \times 9.8} \approx 5.1\,\text{m}$.

6. Range formula derivation: $R = \frac{v_0^2 \sin 2\theta}{g}$.

7. Stone projection:
   (a) Time to hit the ground: $t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 45}{9.8}} \approx 3.03\,\text{s}$.
   (b) Horizontal distance: $d = v_x t = 15 \times 3.03 \approx 45.45\,\text{m}$.

8. Inclined plane projection:
   (a) Use kinematic equations to solve for time of flight considering the inclined angle and initial velocity.

9. Air resistance reduces range and alters trajectory symmetry.

10. Cannon fire:
    (a) Time of flight: $t = \frac{2 v_0 \sin\theta}{g} \approx 8.84\,\text{s}$.
    (b) Maximum height: $h = \frac{v_0^2 \sin^2\theta}{2g} \approx 95.9\,\text{m}$.
    (c) Range: $R = \frac{v_0^2 \sin 2\theta}{g} \approx 441.8\,\text{m}$.

11. Soccer ball:
    (a) Horizontal distance: $d = 63.7\,\text{m}$.
    (b) Time in air: $t = 3.6\,\text{s}$.
    (c) Final velocity: Calculate using $v = \sqrt{v_x^2 + v_y^2}$ just before impact.