

SQ 2.1 State the right-hand rule for two vectors with reference to vector product.

Right-Hand Rule

Curl the fingers of the right hand from the first vector towards the second through the smaller angle. The thumb points in the direction of the vector product.

SQ 2.2 Define impulse and show how it is related to momentum.

Impulse

Impulse is the product of force and the time for which it acts.

Relation

$$J = F\Delta t = mv_f - mv_i = \Delta p.$$

Thus, impulse equals the change in momentum.

SQ 2.3 Differentiate between an elastic and an inelastic collision.

Elastic Collision

Both momentum and kinetic energy are conserved.

Inelastic Collision

Momentum is conserved but kinetic energy is not; some energy changes into heat, sound, or deformation.

SQ 2.4 Show that rate of change of momentum is equal to applied force. Also state Newton's second law in terms of momentum.

Derivation

$$F = ma = m \frac{v_f - v_i}{\Delta t} = \frac{mv_f - mv_i}{\Delta t} = \frac{\Delta p}{\Delta t}.$$

Newton's Second Law

The applied force equals the rate of change of momentum and acts in its direction.

SQ 2.5 State the law of conservation of linear momentum. Also state the condition under which it holds.

Law

The total linear momentum of a system remains constant when no external force acts on it.

Condition

The system must be isolated, so the net external force is zero.

SQ 2.6 Show that the range of a projectile is maximum at an angle of 45° .

Range

$$R = \frac{v_i^2 \sin 2\theta}{g}.$$

Maximum Range

The greatest value of $\sin 2\theta$ is 1. Therefore,

$$2\theta = 90^\circ$$

and

$$\theta = 45^\circ$$

SQ 2.7 Find the time taken by a projectile to reach maximum height.

Vertical Velocity

At maximum height,

$$v_y = 0$$

Using

$$v_y = v_i \sin \theta - gt$$

$$t_H = \frac{v_i \sin \theta}{g}.$$

SQ 2.8 The maximum horizontal range of a projectile is 800 m. Find the height attained by it at $\theta = 60^\circ$.

Initial Speed

For maximum range,

$$R_{max} = v_i^2 / g = 800 \text{ m}$$

Height

$$H = \frac{v_i^2 \sin^2 60^\circ}{2g} = \frac{800(3/4)}{2} = 300 \text{ m}.$$

CRQ 2.1 Why does a hunter aiming directly at a bird in a tree miss the target?

Reason

The projectile follows a curved path under gravity and falls below the straight line of aim. The hunter must aim above the bird to compensate for this drop.

CRQ 2.2 Why is a person falling on a heap of sand less hurt than a person falling on a concrete floor?

Impulse

The same momentum is brought to zero in both cases. Sand increases the stopping time, so

$$F = \Delta p / \Delta t$$

gives a smaller average force.

CRQ 2.3 State the conditions under which birds fly in air.

Flight Forces

A bird remains in steady flight when lift balances weight and thrust balances drag. For upward acceleration, lift exceeds weight; for forward acceleration, thrust exceeds drag.

CRQ 2.4 Describe circumstances in which the velocity and acceleration of a vehicle are: (i) $v = 0$ but $a \neq 0$, (ii) $a = 0$ but $v \neq 0$, and (iii) perpendicular to each other.

Part (i)

At the instant a vehicle starts from rest.

Part (ii)

During uniform motion along a straight road.

Part (iii)

During uniform circular motion, acceleration is towards the centre while velocity is tangential.

CRQ 2.5 Describe briefly the effects of air resistance on the range and maximum height of a projectile.

Effect

Air resistance opposes motion and continually removes mechanical energy. Therefore, both the range and maximum height decrease, and the path is no longer perfectly parabolic.