Solution Set: College Physics I – Kinematics (1D and 2D Motion)

1. Constant Acceleration (1D):

A car starts from rest and accelerates uniformly at 2.5 m/s^2 for 8 seconds.

a) Final velocity:

$v = v_0 + at = 0 + (2.5)(8) = 20$ m/s

b) Distance traveled:

$x = v_0 t + \frac{1}{2}at^2 = 0 + 0.5 \times 2.5 \times 64 = 80$ m

2. Free Fall:

A ball is thrown straight upward with 12 m/s.

a) Time to highest point:

At the top, $v = 0$.

$v = v_0 - gt \implies 0 = 12 - 9.8t \implies t = 1.22$ s

b) Maximum height:

$y = v_0 t - 0.5gt^2 = 12 \times 1.22 - 0.5 \times 9.8 \times (1.22)^2 = 7.32$ m

3. Projectile Motion (2D):

Kicked at 18 m/s at 30°.

a) Time in air:

$v_{0y} = 18\sin\ 30^\circ = 9$ m/s

$t = \frac{2v_{0y}}{g} = \frac{2 \times 9}{9.8} = 1.84$ s

b) Horizontal distance:

$v_{0x} = 18\cos\ 30^\circ = 15.59$ m/s

$x = v_{0x} \times t = 15.59 \times 1.84 = 28.7$ m

4. Relative Velocity:

River east at 2 m/s, boat north at 4 m/s.

a) Speed relative to ground:

$v = \sqrt{2^2 + 4^2} = \sqrt{20} = 4.47$ m/s

b) Angle relative to north:

$\theta = \arctan\left(\frac{2}{4}\right) = 26.6°$ east of north.

5. Kinematics Challenge:

Stone 1 dropped from 45 m; stone 2 thrown up from ground at 15 m/s.

Let y be height above ground where they meet after t seconds.

Stone 1: $y_1 = 45 - 0.5 \times 9.8t^2$

Stone 2: $y_2 = 0 + 15t - 0.5 \times 9.8t^2$

Set $y_1 = y_2$:

$45 - 0.5 \times 9.8t^2 = 15t - 0.5 \times 9.8t^2$

$45 = 15t$

$t = 3.0$ s

Height:

$y = 15 \times 3 - 0.5 \times 9.8 \times 9 = 45 - 44.1 = 0.9$ m above ground.