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Kinematics - Description of how objects move

Displacement - change in position

Average speed - distance traveled in given time

Average velocity - Average speed with direction

Instantaneous velocity - velocity at specific time

Average acceleration - change in speed in given time

Instantaneous acceleration - acceleration at specific time

Gravitational acceleration - a due to gravity ($9.8 m/s^2$)

$\Delta d = v_0 t + \frac{1}{2} a t^2$ $\quad v = v_0 + at$ $\quad v^2 = v_0^2 + 2a\Delta d$

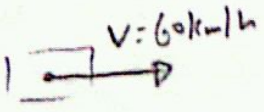
Where d = displacement (m). v = velocity (m/s)

a = acceleration (m/s^2) $\quad t$ = time (s).

Examples

1. Constant velocity:

A car is moving in a straight line at 60km/h. How far will it move in 6s?



Variables: $v_0 = 60\,km/h = 16.667\,m/s$
$t = 6s \quad a = 0$
$d = ?\ m$

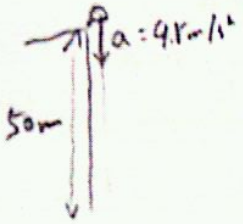
Formula: $\Delta d = v_0 t + \frac{1}{2} a t^2$

Solve: $\Delta d = (16.667\,m/s)(6s) + \frac{1}{2}(0)(6s)^2$

$= 100\,m + 0 = \boxed{100\,m}$

2. Constant acceleration:

A rock is dropped from a 50m high cliff. After how many seconds does it hit the ground?



Variables: $v_0 = 0$
$a = -9.8\,m/s^2$
$d = -50\,m$
$t = ?\ s$

Formula: $\Delta d = v_0 t + \frac{1}{2} a t^2$

Solve: $-50\,m = (0)t + \frac{1}{2}(-9.8\,m/s^2)t^2$

$-50\,m = (-4.9\,m/s^2)t^2$

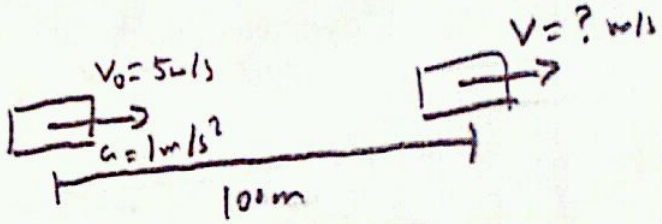
$t^2 = \frac{-50\,m}{-4.9\,m/s^2}$

$t = \boxed{3.19\,s}$

3. Velocity

A car moving 5 m/s accelerates 1 m/s². How fast is the car when its displacement is 100 m?

Variables: $v_0 = 5\ m/s$
$a = 1\ m/s^2$
$d = 100\ m$
$v = ?\ m/s$



Formula: $v^2 = v_0^2 + 2ad$

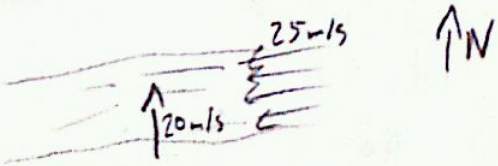
Solve: $v^2 = (5\ m/s)^2 + 2(1\ m/s^2)(100\ m)$

$v^2 = 225\ m^2/s^2$

$v = \sqrt{225}\ m/s = 15\ m/s$

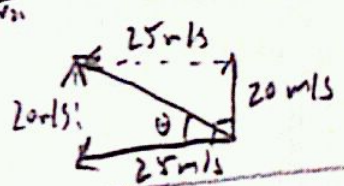
4. River-boat Problem (relative velocity)

A waterproof robot is attempting to swim across a river. If the robot is swimming north at a rate of 20 m/s, and the river is flowing west at a rate of 25 m/s, what is the robot's velocity relative to the shore?



Variables: $v_{river} = 25\ m/s$
$v_{robot} = 20\ m/s$

Formula: $v^2 = v_x^2 + v_y^2$ $\theta = \tan^{-1}\frac{v_y}{v_x}$



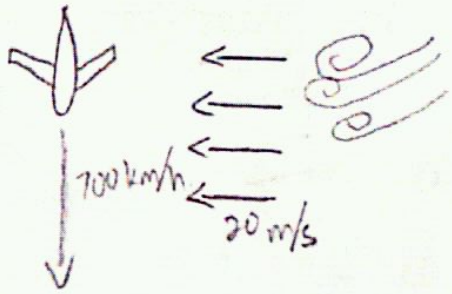
$v^2 = (25\ m/s)^2 + (20\ m/s)^2$

$v = 32.0\ m/s$

$\theta = \tan^{-1}\left(\frac{20}{25}\right) = 39.0°$ (north of west)

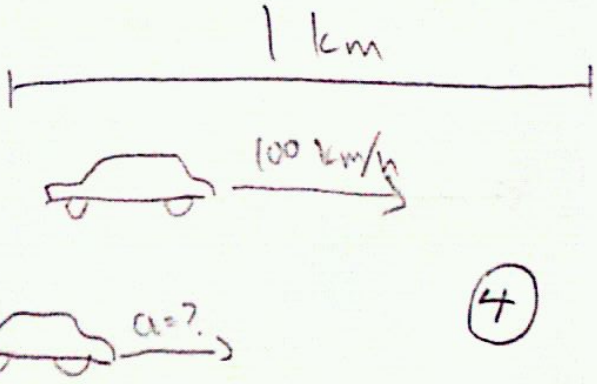
1. A plane travels at 700 km/h from North to South. A gust of wind blowing at 20 m/s uniformly from East to West. After 4 hours, how far is it from its original position? 8S

a. 2801 km
b. 2800 km
c. 781 km
d. 2815 km



2. A hitman has been stalking his target for days in his car. He was grabbing a burger at a diner when he saw his target speeding by in his car at 100 km/h. Assuming it takes the hitman 10 s to get to his car and chase while accelerating from rest. At what rate does he have to accelerate to catch up to his target before he turns into an alley 1 km away?

a. 2.96 m/s²
b. 1.54 m/s²
c. 1.00 m/s²
d. 5.92 m/s²



(4)

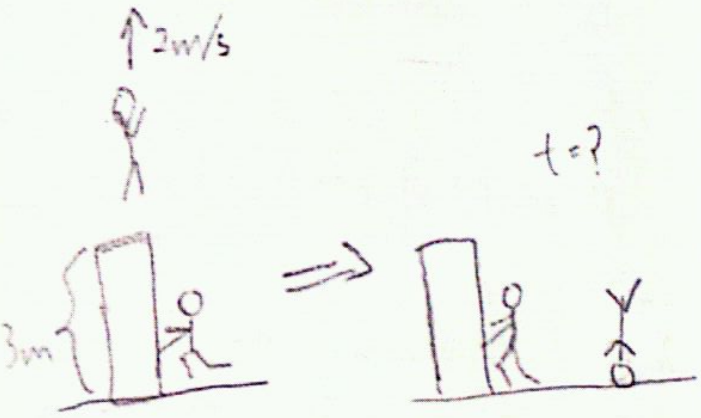
3. A guy jumps straight up on a 3 m tall platform. His friend thought it would be funny to pull the platform from under him. How long does he spend in the air before he cracks head open. Assume he jumps with initial velocity of 2 m/s.

a. 0.665 s

b. 0.782 s

c. 1.01 s

d. 0.408 s



Solutions

JS

1. $700 \times 4 = 2800$ km

$20 \text{ m/s} \cdot \frac{1000}{3600} = 72$ km/hr.

$72 \cdot 4 = 288$ km

$2800^2 + 72^2 = d^2$

$d = 2815$ km (D)

2. $100 \cdot 1000/3600 = 27.\overline{7}$ m/s.

$1000/27.\overline{7} = 36$ s

$36 - 10 = 26$ s

$\Delta d = \frac{1}{2} a t^2$

$1000 = \frac{1}{2} a (26)^2$

$a = 2.96 \text{ m/s}^2$ (A)

3. $\Delta d = V_0 t + \frac{1}{2} a t^2$

$-3 = 2t - 4.9t^2$

$t = 1.01$ s (C)