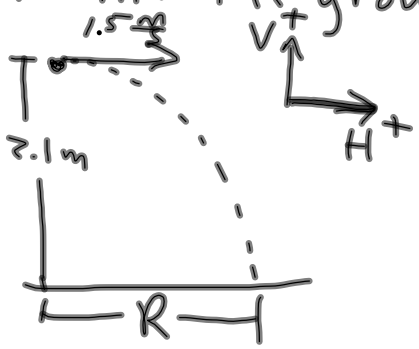
Projectile Motion

Motion in the vertical direction is independent of motion in the horizontal direction.

(.. you can treat them separately.)

Situation ① - Launching Horizontally

A ball bearing is ejected horizontally at a speed of $1.5 \frac{m}{s}$ from a height of 2.1 m. How far away (hor.) does it hit the ground?



vert.

$V_i = 0$

$V_f = ?$

$a = -9.8 \frac{m}{s^2}$

$d = -2.1 m$

$t = ?T$

hor.

$V = 1.5 \frac{m}{s}$

$\boxed{d = R}$

$t = T$

Vert...

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

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

$-2.1 = \frac{1}{2}(-9.8) T^2$

$T^2 = \frac{2.1}{4.9}$

$T = 0.65 s$

Hor....

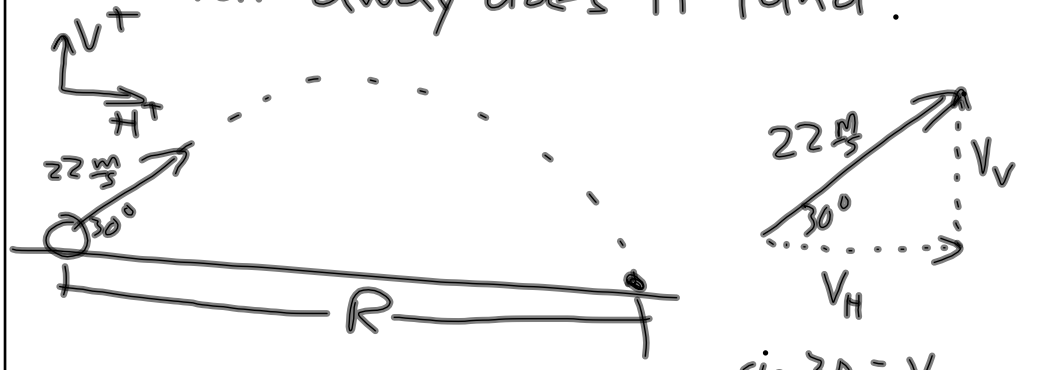
$d = vt$

$R = (1.5)(0.65)$

$= 0.98 m$

Situation (2) - Launched at an angle on level ground

A ball is kicked at a velocity of 22 $\frac{m}{s}$ [30° above the horizontal]. How far away does it land?



$\sin 30 = \frac{V_V}{22}$

$\therefore V_V = 22 \sin 30$

$= 11 \frac{m}{s}$

$V_H = 22 \cos 30$

$= 19.1 \frac{m}{s}$

V

$V_i = 11 \frac{m}{s}$ ✓

$V_f = ?$

$a = -9.8 \frac{m}{s^2}$ ✓

$d = 0$ m ✓

$t = T$ ✓

H

$v = 19.1 \frac{m}{s}$

$t = T$

$d = R$

$d = vt$

$= (19.1)(2.24)$

$= 42.9$ m

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

$0 = 11T - 4.9T^2$

$0 = T(11 - 4.9T)$

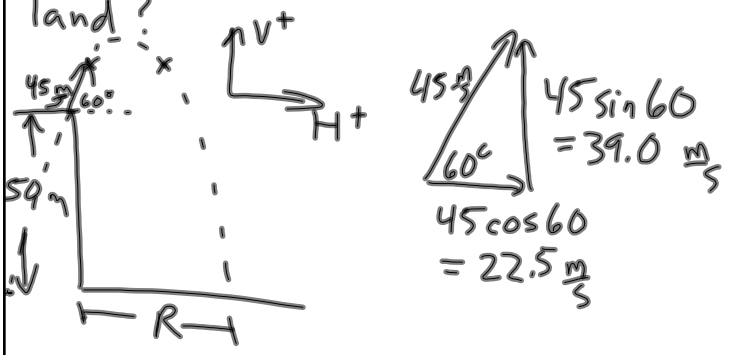
$T = 0$ or $11 - 4.9T = 0$

$11 = 4.9T$

$T = 2.24$ s

Sit. 3 → Launched at an angle: non-level ground

An arrow is launched at a speed of $45 \frac{m}{s}$, 60° above the horizontal, from the top of a 50 m high cliff. How far from the base of the cliff does it land?



V

$v_i = 39 \frac{m}{s}$

$a = -9.8 \frac{m}{s^2}$

$d = -50\ m$

$t = T$

H

$t = T$

$v = 22.5 \frac{m}{s}$

$d = R$

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

$-50 = 39T - 4.9T^2$

$0 = -4.9T^2 + 39T + 50$

$$T = \frac{-39 \pm \sqrt{39^2 - 4(-4.9)(50)}}{2(4.9)}$$

$$= \frac{-39 \pm \sqrt{1521 + 980}}{9.8}$$

$$= \frac{-39 + 50}{-9.8} \text{ or } \frac{-39 - 50}{-9.8}$$

$T < 0$

$$T = \frac{-89}{-9.8}$$

$= 9.08\ s$

Hor.

$d = v t$

$= (22.5)(9.08)$

$= 204\ m$