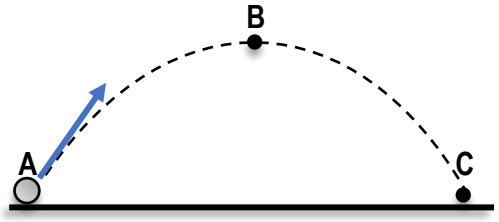
## CONCEPT: USING SPECIAL EQUATIONS IN SYMMETRICAL LAUNCH PROBLEMS

● For symmetrical launches *ONLY* ($y_f = y_0$), remember: $t\uparrow = t\downarrow$ $v\uparrow = -v\downarrow$ $|v_c| = |v_a|$ $\theta_c = -\theta_a$

- In addition, there are even more special equations you may be allowed to use!

EXAMPLE: A catapult launches a projectile with 100m/s at 53° upwards. The projectile later returns to the ground. Find:

**a)** the time the projectile hits the ground




**TOTAL TIME OF FLIGHT**

$t_{sym} = \Delta t_{AC} =$ _____

**b)** horizontal range of the projectile

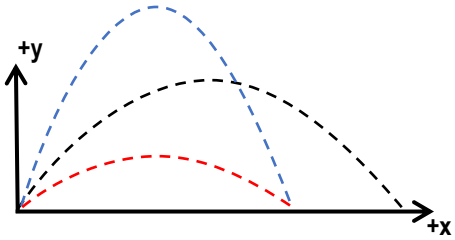
**c)** the other launch angle that gives the same range

**TOTAL HORIZONTAL DISPLACEMENT (aka RANGE)**

If you have $t_{AC}$: $R_{sym} = \Delta x_{AC} = v_x t_{AC}$

If you don't have $t_{AC}$: $R_{sym} = \Delta x_{AC} =$ _____

- MAXIMUM when launch angle **θ =** ____.
- Complementary angles (i.e. $\theta_1 + \theta_2$ = ____, e.g ____& ____) achieve same $R$ for same $v_0$.



PROBLEM: A frog leaves the ground with a speed of 15 m/s and stays in the air for 2.0s. At what angle did the frog jump?

**A)** 40.8°
**B)** 9.4°
**C)** 19.1°

**SPECIAL EQUATIONS**

$$t_{\text{sym}} = \Delta t_{AC} = \frac{2v_0 sin\theta}{g}$$

$$R_{sym} = \Delta x_{\text{AC}} = \frac{v_0^2 sin(2\theta)}{g}$$

PROBLEM: A champion long-jumper competing on Planet X is capable of leaving the ground with a speed of 6 m/s. The maximum distance he can cover on Planet X turns out to be 9 m. What is the gravity on Planet X?

**A)** 0.75 m/s$^2$
**B)** 4.0 m/s$^2$
**C)** 2.1 m/s$^2$
**D)** 12 m/s$^2$

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PROBLEM: A golf ball is hit at ground level at an angle of 31.9° above the horizontal. Its range is 257 m over a level green. What was the magnitude of the golf ball's initial velocity?

**A)** 2807 m/s
**B)** 69 m/s
**C)** 95 m/s
**D)** 53 m/s

**SPECIAL EQUATIONS**

$$t_{\text{sym}} = \Delta t_{AC} = \frac{2v_0 sin\theta}{g}$$

$$R_{sym} = \Delta x_{\text{AC}} = \frac{v_0^2 sin(2\theta)}{g}$$