

CONCEPT: USING SPECIAL EQUATIONS IN SYMMETRICAL LAUNCH PROBLEMS

- For symmetrical launches ONLY ($y_f = y_0$), remember:

$$t_{\uparrow} = t_{\downarrow}$$

$$v_{\uparrow} = -v_{\downarrow}$$

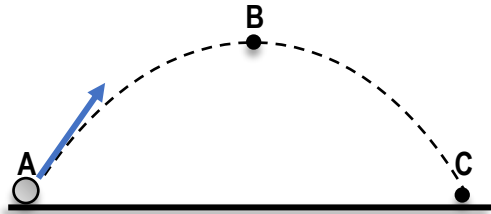
$$|v_c| = |v_a|$$

$$\theta_c = -\theta_a$$

- 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

$$t_{sym} = \Delta t_{AC} = \underline{\hspace{2cm}}$$

- b) horizontal range of the projectile

TOTAL HORIZONTAL DISPLACEMENT (aka RANGE)

If you have t_{AC} :

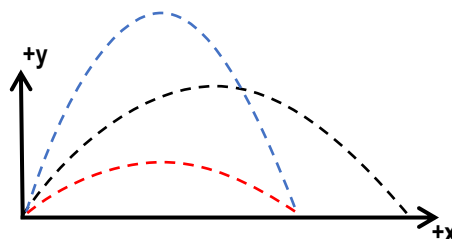
$$R_{sym} = \Delta x_{AC} = v_x t_{AC}$$

If you don't have t_{AC} :

$$R_{sym} = \Delta x_{AC} = \underline{\hspace{2cm}}$$

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

- MAXIMUM when launch angle $\theta = \underline{\hspace{1cm}}$.
- Complementary angles (i.e. $\theta_1 + \theta_2 = \underline{\hspace{1cm}}$, e.g. $\underline{\hspace{1cm}}$ & $\underline{\hspace{1cm}}$) 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

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

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

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

SPECIAL EQUATIONS

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