

Solving Newton's 3rd Law Word Problems – Objects Moving Apart

THE PERFECT SOLUTION (FOR FORCE PROBLEMS):

- 1a. Sketch a quick diagram of the entire situation
- 1b. Draw a FBD for the relevant object(s) and then choose your positive coordinate system
2. Write out all variables with signs and units
3. Convert units to m, s, or kg
4. Pick the appropriate equation – box it
5. Rearrange for the variable you need
6. Sub in numbers in brackets
7. Type into calculator in one step
8. Answer with units and direction – circle it

time taken for the ball to leave the cannon is 0.06 s

1. A cannon with perfectly frictionless wheels has a weight of 2450 N and shoots a 20-kg cannonball horizontally so that it leaves the barrel with a velocity of 50 m/s [fwd]. If the barrel of the cannon is 1.5 m long, calculate the velocity at which the cannon is moving after the shot is fired.

$F_g = 2450 \text{ N}$
 $F_g = mg$
 $m = \frac{F_g}{g}$
 $= \frac{2450 \text{ N}}{9.8 \frac{\text{N}}{\text{kg}}}$
 $= 250 \text{ kg}$

$m = 20 \text{ kg}$
 $v = 50 \frac{\text{m}}{\text{s}}$

FBD Cannon
 F_N (up), F_g (down), $F_{B,C}$ (left)

FBD Ball
 F_N (up), F_g (down), $F_{C,B}$ (right)

$F_{net} = ma$
 $F_{net} = (20)(833.3)$
 $= 16,666.7 \text{ N} [\rightarrow]$

$v_1 = 0$
 $v_2 = +50 \frac{\text{m}}{\text{s}}$
 $a = ?$
 $ad = ?$
 $at = 0.06 \text{ s}$

$a = \frac{v_2 - v_1}{\Delta t}$
 $= \frac{+50 \frac{\text{m}}{\text{s}} - 0}{0.06 \text{ s}}$
 $a = 833.3 \frac{\text{m}}{\text{s}^2}$

Cannon
 $v_1 = 0$
 $v_2 = ?$
 $a = -66.7 \frac{\text{m}}{\text{s}^2}$
 $ad = ?$
 $at = 0.06 \text{ s}$

$F_{net} = 16,666.7 \text{ N} [\leftarrow]$
 $F_{net} = ma$
 $a = \frac{F_{net}}{m}$
 $= \frac{-16,666.7 \text{ N}}{250 \text{ kg}}$
 $a_{cannon} = -66.7 \frac{\text{N}}{\text{kg}}$
 $= -66.7 \frac{\text{m}}{\text{s}^2}$

the time of the 2 objects pushing on each other is always the same

$a = \frac{v_2 - v_1}{\Delta t}$
 $v_2 = at + v_1$
 $= (-66.7)(0.06 \text{ s})$
 $= -4.002 \frac{\text{m}}{\text{s}}$
 $\therefore \vec{v}_2 = 4.0 \frac{\text{m}}{\text{s}} [\leftarrow]$