Momentum 3

① $m_1 v_1 + m_2 v_2 = (m_1 + m_2) v$

$3 \times 10^5 (2.2) + 3 \times 10^5 (0) = (3 \times 10^5 + 3 \times 10^5) v$

$660\,000 = 600\,000 v$

$v = \boxed{1.1 \text{ m/s}}$

② $m_1 v_1 + m_2 v_2 = (m_1 + m_2) v$

$(0.105)(24) + (75)(0) = (0.105 + 75) v$

$2.52 = 75.105 v$

$v = \boxed{0.034 \text{ m/s}}$

③ $m_1 v_1 + m_2 v_2 = (m_1 + m_2) v$

$(0.035) v_1 + (5)(0) = (0.035 + 5)(8.6)$

$0.035 v_1 = 43.301$

$v_1 = \boxed{1237.2 \text{ m/s}}$

④ $m_1 v_1 + m_2 v_2 = m_1 v_1' + m_2 v_2'$

$(0.035)(475) + (2.5)(0) = (0.035)(275) + (2.5) v_2'$

$16.625 = 9.625 + 2.5 v_2'$

$7 = 2.5 v_2'$

$v_2' = \boxed{2.8 \text{ m/s}}$

⑤ $m_1v_1 + m_2v_2 = m_1v_1' + m_2v_2'$

$(0.5)(6) + (1)(-12) = (0.5)(-14) + (1)v_2'$

$-9 = -7 + v_2'$

$v_2' = \boxed{-2 \text{ m/s}}$

⑥ $(m_1+m_2)v = m_1v_1 + m_2v_2$

$(4+0.05)(0) = (4)v_1 + (0.05)(-625)$

$0 = 4v_1 - 31.25$

$4v_1 = 31.25$

$v_1 = \boxed{7.81 \text{ m/s}}$

⑦ $(m_1+m_2)v = m_1v_1 + m_2v_2$

$(1.5+4.5)(0) = (1.5)(-27) + (4.5)v_2$

$0 = -40.5 + 4.5v_2$

$4.5v_2 = 40.5$

$v_2 = \boxed{9 \text{ cm/s}}$

⑧ $(m_1 + m_2)v = m_1 v_1 + m_2 v_2$

$(80 + 115)(0) = (80)(4) + (115) v_2$

$0 = 320 + 115 v_2$

$115 v_2 = -320$

$v_2 = \boxed{-2.78 \text{ m/s}}$

⑨ a) This question combines momentum and projectile motion.

Projectiles

Ball: $v_b = \frac{d}{t}$ Cannon: $v_c = \frac{d}{t}$

$v_b = \frac{215}{t}$ $t = \frac{d}{v_c}$

$t = \frac{215}{v_b}$

Since the ball + cannon hit the ground in the same amount of time...

$\frac{215}{v_b} = \frac{d}{v_c}$

$v_c = \frac{d \cdot v_b}{215}$ equation 1

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⑨ Momentum

$$(m_b + m_c)\,v = m_b v_b + m_c v_c$$

$$(225 + 4.5)(0) = (4.5)\,v_b + (225)\,v_c$$

$$0 = 4.5\,v_b + 225\,v_c$$

$$-4.5\,v_b = 225\,v_c$$

$$v_c = \frac{-4.5\,v_b}{225} \qquad \text{equation 2}$$

2 Equations, 2 unknowns

$$v_c = \frac{d \cdot v_b}{215} = \frac{-4.5\,v_b}{225}$$

$$\frac{d \cdot v_b}{215} = \frac{-4.5\,v_b}{225}$$

$$d = \frac{-4.5(215)}{225}$$

$$d = \boxed{-4.3\ m}$$

b) Since there is no friction, the width of the tower doesn't matter.