(1) $\vec{V}_{CG}$ = Velocity of the car w.r.t ground

$= 80\ Km/hr = 80\hat{i}$

$\vec{V}_{TG}$ = Velocity of the truck w.r.t ground

$= 70\ Km/hr = -70\hat{j}$

$\vec{V}_{CT} = ?$

$\vec{V}_{CT} = \vec{V}_{CG} + \vec{V}_{GC} = 80\hat{i} - 70\hat{j}$

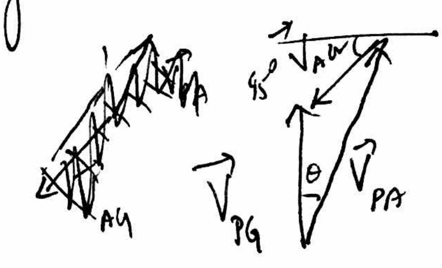
$|V_{CT}| = \sqrt{80^2 + (-70)^2} =$ **106.0 Km/hr**

$\theta = \tan^{-1}\left(\frac{-70}{80}\right) =$ **41.2° N**

(2) $\vec{V}_{PA}$ = Velocity of plane w.r.t. air = 300 Km/hr

$\vec{V}_{AG}$ = Velocity of wind w.r.t ground = 90 Km/hr @ 225°

$\left(\vec{V}_{PG} = \vec{V}_{PA} + \vec{V}_{AG}\right)_{x,y}$



$\vec{V}_{AG} = -90\cos 45\hat{i} - 90\sin 45\hat{j}$

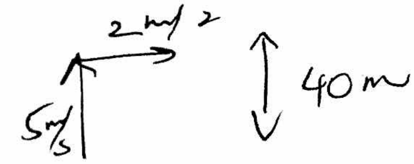
$\vec{V}_{PA} = 300\cos\theta\hat{i} + 300\sin\theta\hat{j}$

$0\hat{i} = -90\cos 45\hat{i} + 300\cos\theta\hat{j}$

θ = N12°E

$\vec{V}_{PG} = |V_{PG}|\hat{j} = (300\sin\theta)\hat{j} - (90\sin 45)\hat{j} \Rightarrow$ **$|V_{PG}| = 230$ Km/h**

(3) $V_y = \frac{\Delta y}{t} = 5\,m/s$



$\Delta y = 40m$ (given)

$\Rightarrow 5 = \frac{40}{t} \Rightarrow t = 8s$

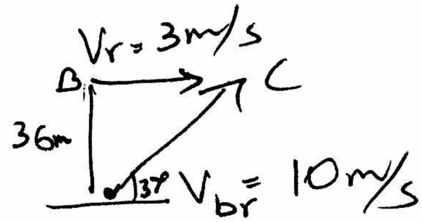
(Note Velocity of boat w.r.t river (V_{BR}) means in still waters)

time for x is = time for y

$\Rightarrow$ 8s can be used in x direction calculations

$\Rightarrow \vec{AB} = \Delta x = \vec{V}_{RG} * t = 2 \times 8 = \boxed{16m}$

(4) In y-direction



$V_{br} \sin 37^\circ = V_y$

$\Delta y = 36\,m$

$V_y = \frac{\Delta y}{t} \Rightarrow t = \frac{36}{10 \cdot \sin 37} = \frac{36}{6} = \boxed{6s}$

In x direction

Velocity $= V_x = 3 + V_{br} \cos 37 = 11\,m/s$

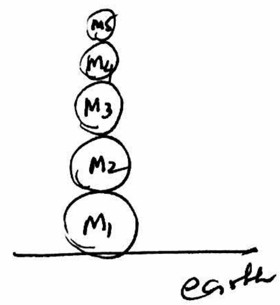
$\Rightarrow BC = \Delta X = V_x * t = 11 * 6 = \boxed{66m}$

Stacked balls problem

first collision happens between m_1 & earth.

Relative to earth $V_{earth} = 0$

We will use elastic collision equation which is a combination of
$P_i = P_f$ & $K_i = K_f$.



$$V_{ef} = \frac{(m_e - m_1)}{(m_e + m_1)} V_{ei} + \frac{2m_1}{(m_e + m_1)} V_{1i}$$

As $m_1 \ll m_2$

We'll consider downward vector as +ve

$V_{ef} = 0$

$$V_{1f} = \frac{2m_e}{(m_e + m_1)} V_{ei} + \frac{(m_1 - m_e)}{(m_e + m_1)} V_{1i}$$

Again as $m_1 \ll m_2$ ignore m_1

$\boxed{V_{1f} = -V_{1i}}$ This means that 1st ball rebounds with the same velocity as it came.

As all the balls are falling with the same velocity of V_i we will call $\boxed{V_{1i} = V_i} = V_{2i} = V_{3i} = V_{4i} = V_{5i}$

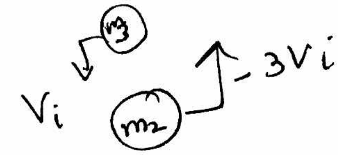
Using

$$V_{2f} = \frac{(m_2 - m_1)}{(m_2 + m_1)} V_{2i} + \frac{2m_1}{(m_2 + m_1)} V_{1i} = -V_i + 2V_i \boxed{= -3V_i}$$

Similarly.

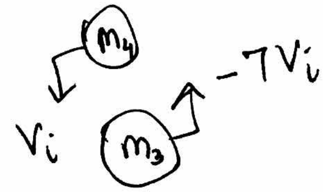
Stacked ball problems

$$V_{3f} = \frac{(m_3 - m_2)}{(m_2 + m_3)} V_{3i} + \frac{2m_2}{(m_2 + m_3)} V_{2i}$$



As $m_3 << m_2$ m_3 is ignored

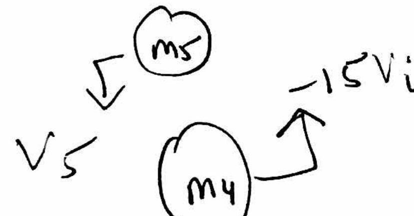
$$V_{3f} = -V_{3i} + 2(V_{2i}) = -V_i - 2(3V_i) = \boxed{7V_i}$$



Similarly

$$V_{4f} = -V_i - 2(7V_i) = \boxed{15V_i}$$

$$V_{5f} = -V_i - 2(15V_i) = \boxed{-31V_i}$$



We know that the balls falls from 1 m.

applying kinematics

$$V_i^2 = 2g\,\Delta y \Rightarrow 2g$$

$$\Rightarrow \boxed{V_i = 4.42 \text{ m/s}}$$

Hence $V_{5f} = -31 \times 4.42$ m

Solving for height reached with this initial speed

$$\boxed{\Delta h \approx 3969 \text{ m}}$$