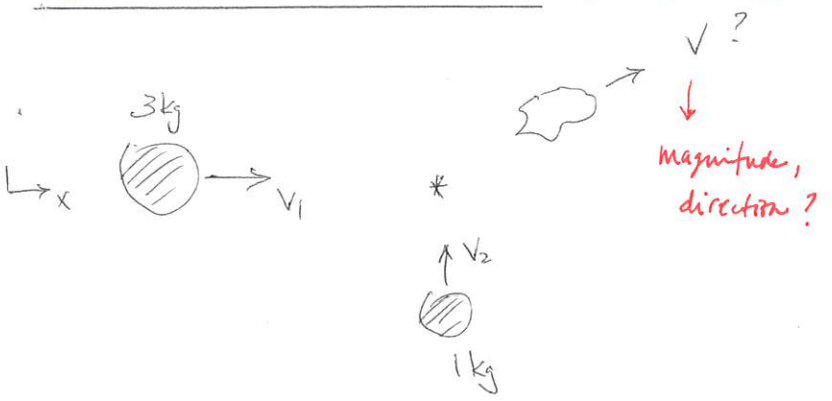
## 2D Inelastic collision (treat each direction separately)




$v_1 = 1$ m/s

$v_2 = 10$ m/s

$$\left.\begin{aligned} \vec{P}_0 &= \vec{P}_f \\ \vec{P}_1 + \vec{P}_2 &= \vec{P}_f \end{aligned}\right\} \Rightarrow \begin{aligned} P_{1x} + P_{2x} &= P_x \\ P_{1y} + P_{2y} &= P_y \end{aligned}$$

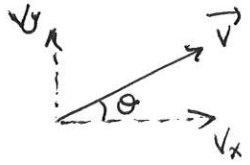
$$x: \quad P_{1x} + P_{2x} = P_x \rightarrow m_1 v_1 + m_2(0) = (m_1+m_2) v_x$$

$$y: \quad P_{1y} + P_{2y} = P_y \rightarrow m_1(0) + m_2 v_2 = (m_1+m_2) v_y$$

So $$v_x = \frac{m_1 v_1}{m_1+m_2} = \frac{3(1)}{3+1} = 0.75 \text{ m/s}$$

$$v_y = \frac{m_2 v_2}{m_1+m_2} = \frac{1(10)}{4} = 2.5 \text{ m/s}$$

$$\therefore \quad \vec{v} = (0.75\hat{i} + 2.5\hat{j}) \text{ m/s};$$




$$v = \sqrt{v_x^2 + v_y^2} = 2.61 \text{ m/s}$$

$$\tan\theta = \frac{v_y}{v_x} = 3.33 \Rightarrow \theta = 73°$$

How much KE is lost?

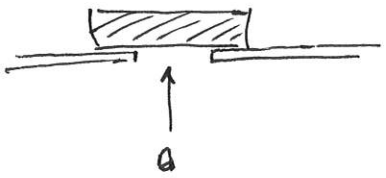
$$K_0 = \frac{1}{2} m v_1^2 + \frac{1}{2} m_2 v_2^2 = \frac{1}{2}(3)(1)^2 + \frac{1}{2}(1)(10)^2 = 51.5 \text{ J}$$

$$K_f = \frac{1}{2}(m_1+m_2) v^2 = \frac{1}{2}(4)(2.61)^2 = 13.6 \text{ J}$$

$\Rightarrow$ 74% of $K_0$ is lost.

- An exercise to combine conservation laws:

Bullet $m = 21g$, $V = 310$ m/s, hits 1.4 kg block
How high will the block 'jump' after the bullet is embedded in it?



- Apply momentum conservation to the collision

$$P_0 = m_b \cdot V_b = 0.021\ kg \cdot 310\ m/s = 6.51\ kg \cdot m/s$$

$$P_f = (m_b + m_{block})\, V_f = (1.421\ kg)\, V_f$$

$$\therefore \quad V_f = \frac{6.51}{1.421} = 4.58\ m/s$$

- Apply conservation of energy to the "jump" part:

$$E_0 = E_f$$

$$\frac{1}{2}(m_b + m_{block})\, V_f^2 = (m_b + m_{block})\, g\, h$$

$$\frac{1}{2}(1.421)(4.58)^2 = (1.421)(9.8)\, h$$

$$h = 1.07\ m$$