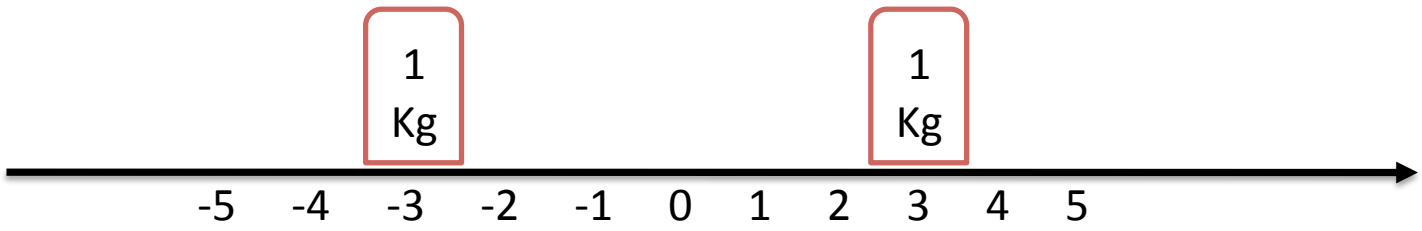
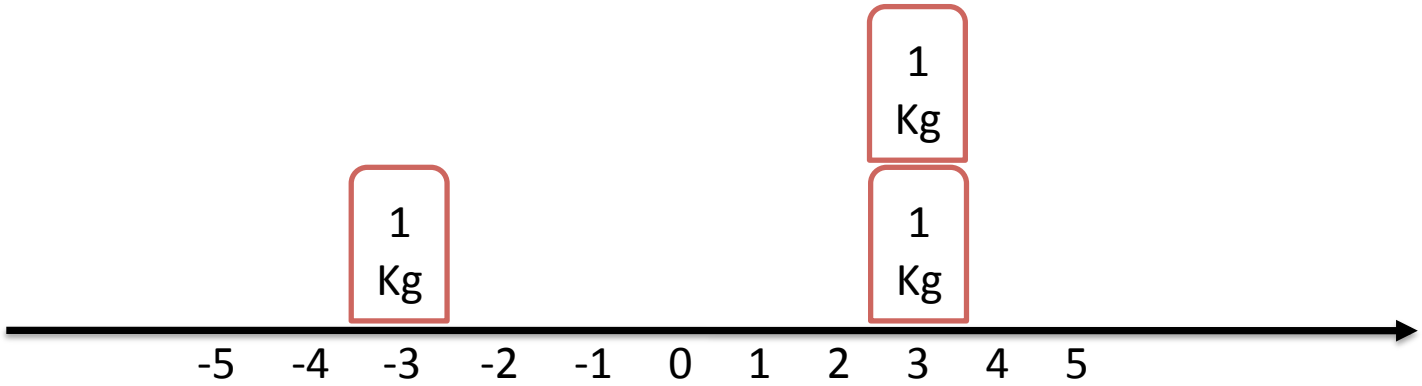
Center of mass



Center of mass (a) -3 (b) 0 (c) 6



Center of mass (a) 0 (b) 3 (c) 1

Formula for center of mass position

Two bodies

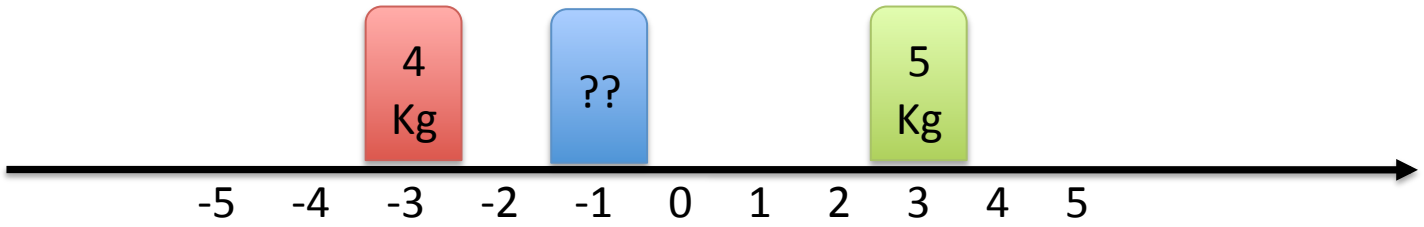
$$x_{cm} = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2}$$

Three bodies

$$x_{cm} = \frac{m_1 x_1 + m_2 x_2 + m_3 x_3}{m_1 + m_2 + m_3}$$

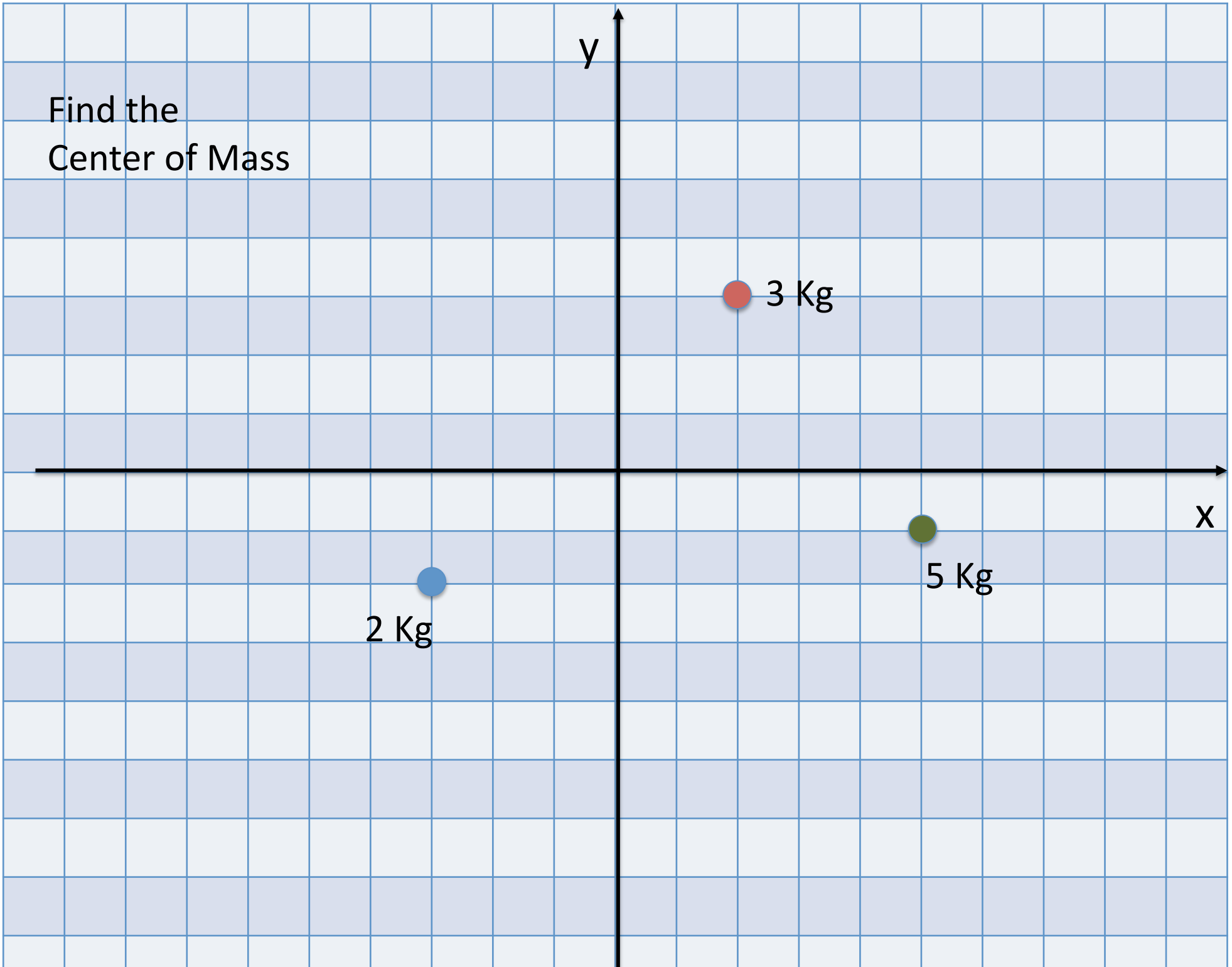
General

$$x_{cm} = \frac{m_1 x_1 + m_2 x_2 + \cdots + m_k x_k}{m_1 + m_2 + \cdots + m_k}$$



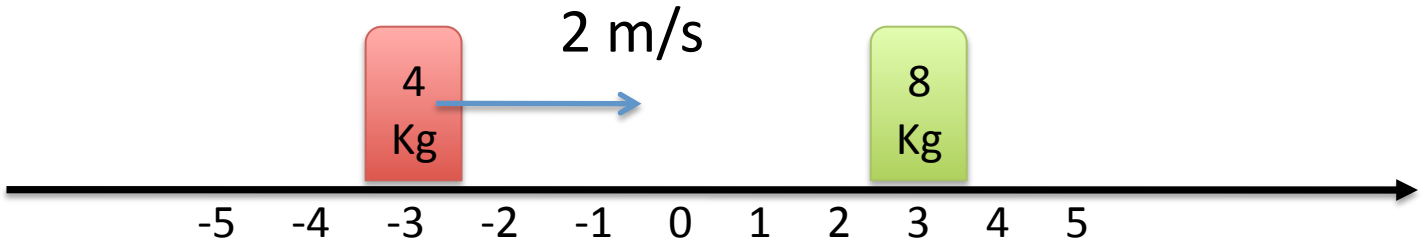
Center of mass is at 0. What is the blue mass ?

Ans: 3 Kg


Find the
Center of Mass
y
x
3 Kg
5 Kg
2 Kg

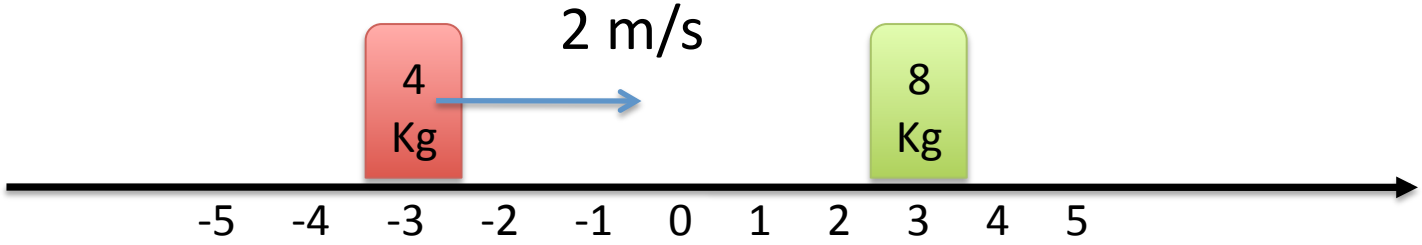
What is the velocity of the center of mass ?

t=0



$$x_1 = -3 + 2t$$

$$x_2 = 3$$



At time t $x_1 = -3 + 2t$

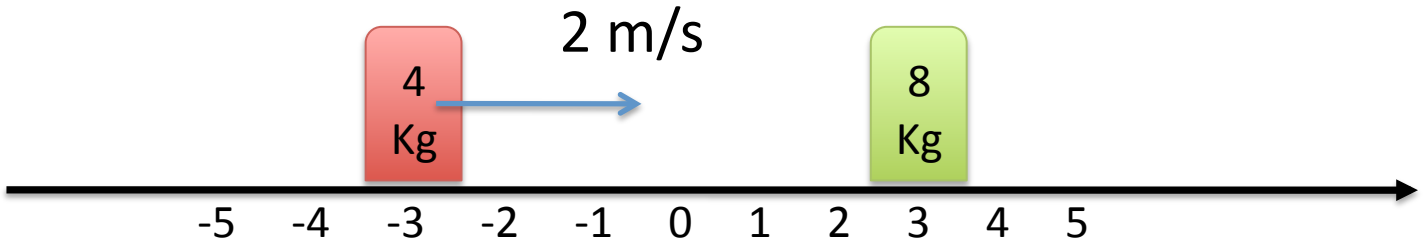
$$x_2 = 3$$

$$x_{cm} = \frac{4(-3+2t)+8(3)}{4+8}$$

$$= \frac{12+8t}{12}$$

$$= 1 + \frac{2}{3}t \qquad \Rightarrow \quad v_{cm} = \tfrac{2}{3} m/s$$

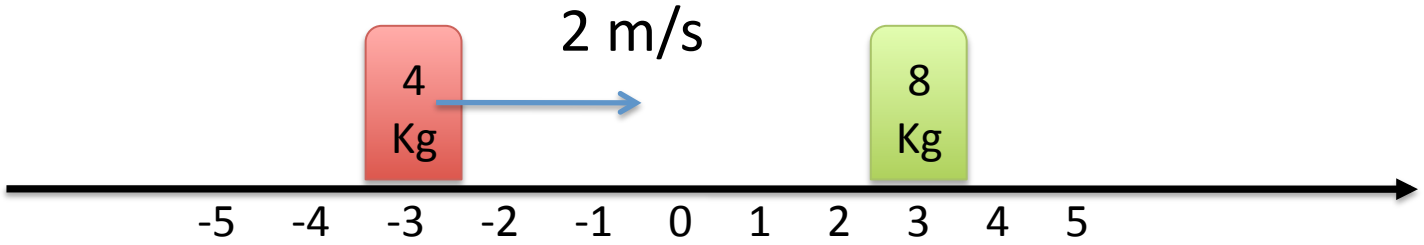
Is v_{cm} the average velocity of the two blocks ?



$$\text{Weighted average velocity} = \frac{4(2)+8(0)}{4+8} = \frac{8}{12} = \frac{2}{3}\, m/s$$

So velocity of the center of mass is the weighted average of the velocities of the blocks

What can the velocity of center of mass tell us about momentum ?



$$\text{Total momentum} = P_T = 4(2) + 8(0) = 8 \ kg\, m/s$$

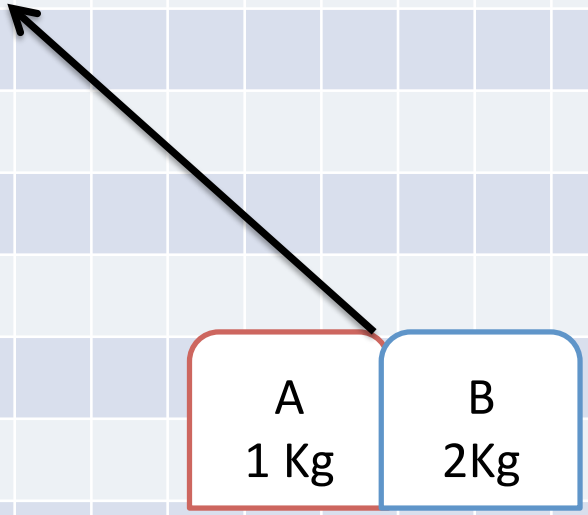
$$\text{Total mass} = M_T = 4 + 8 = 12 \ kg$$

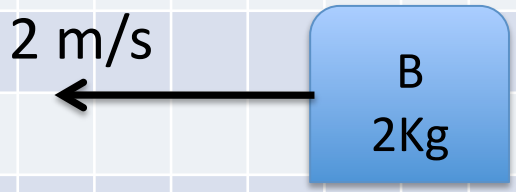
So we observe that

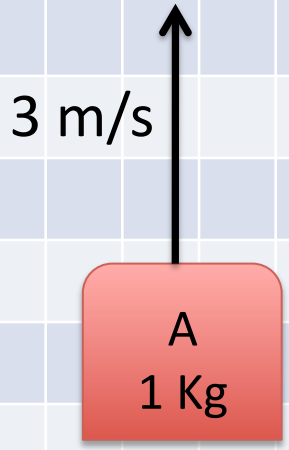
$$P_T = M_T \, v_{cm}$$

Momentum in 2-d

Find magnitude and direction of final velocity



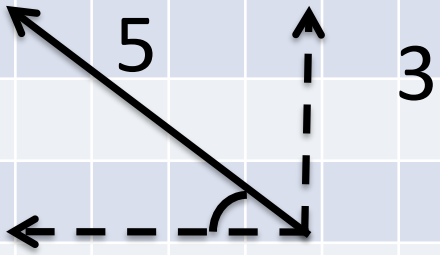


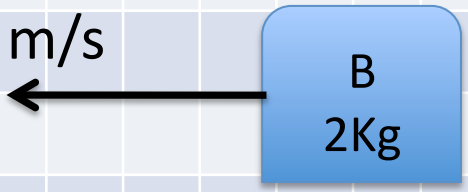


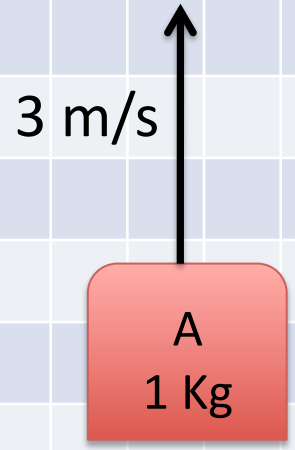
$$\cos\theta = \frac{4}{5}$$

velocity = 5/3 m/s

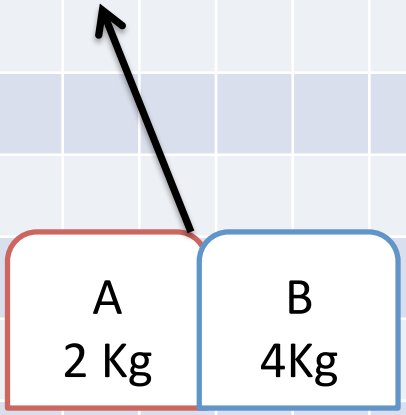
momentum vector

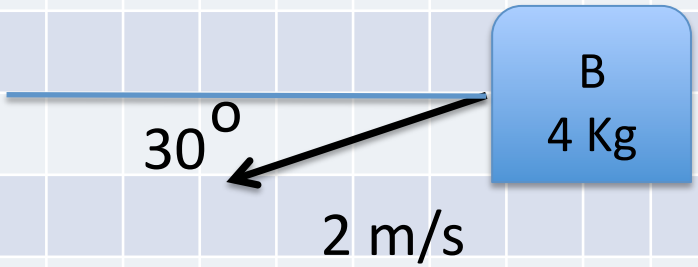


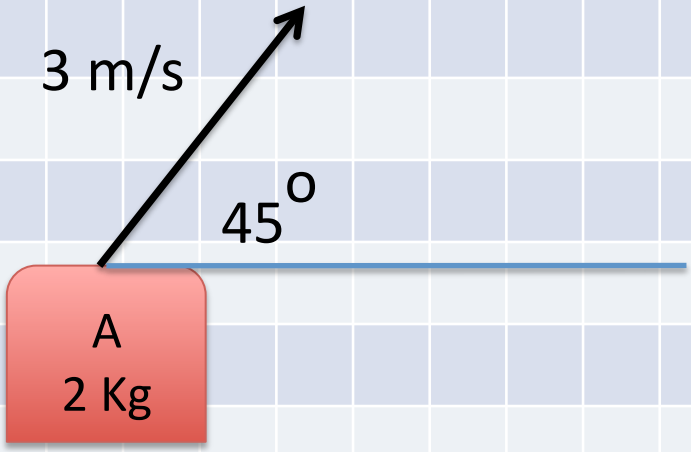


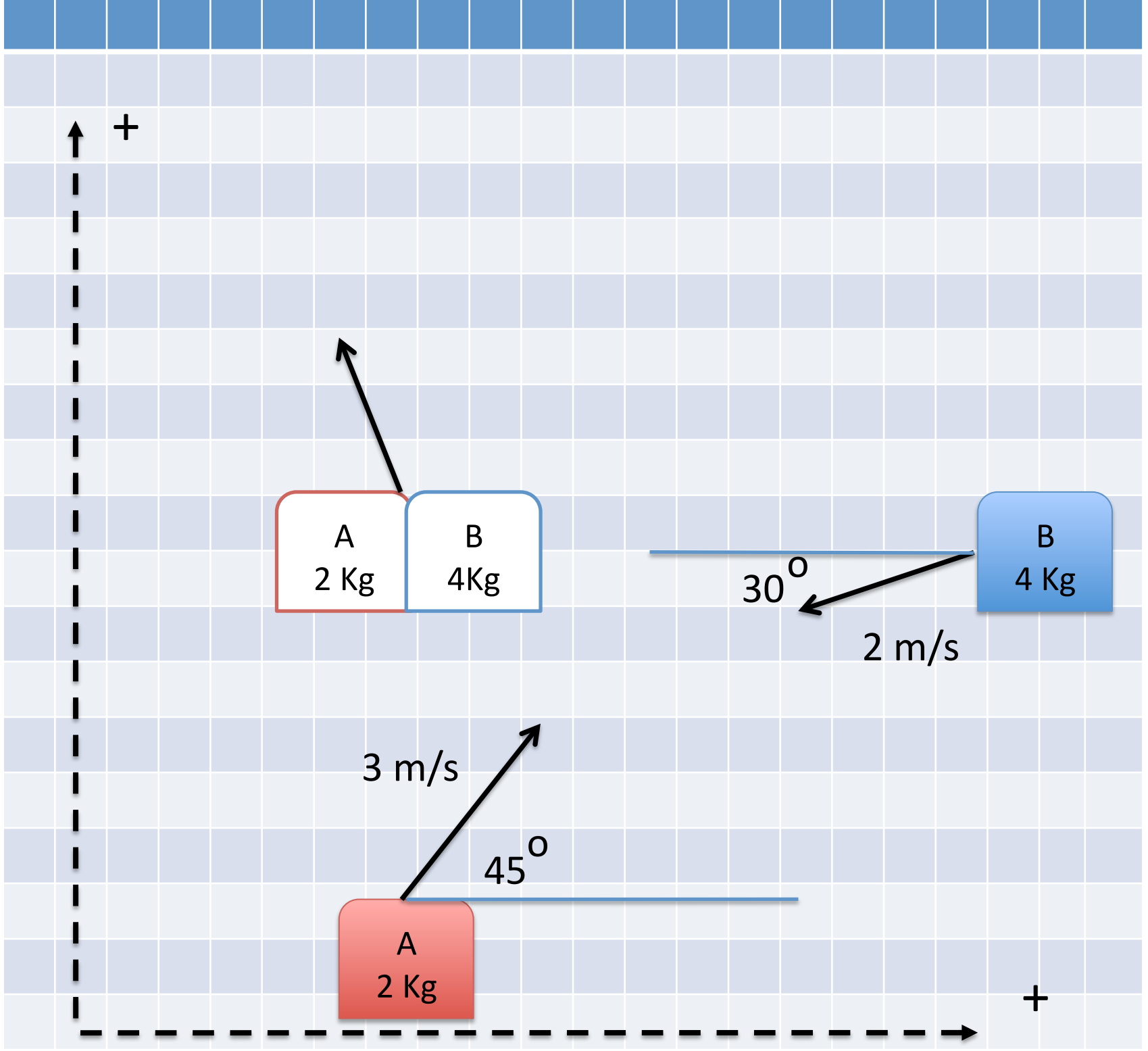


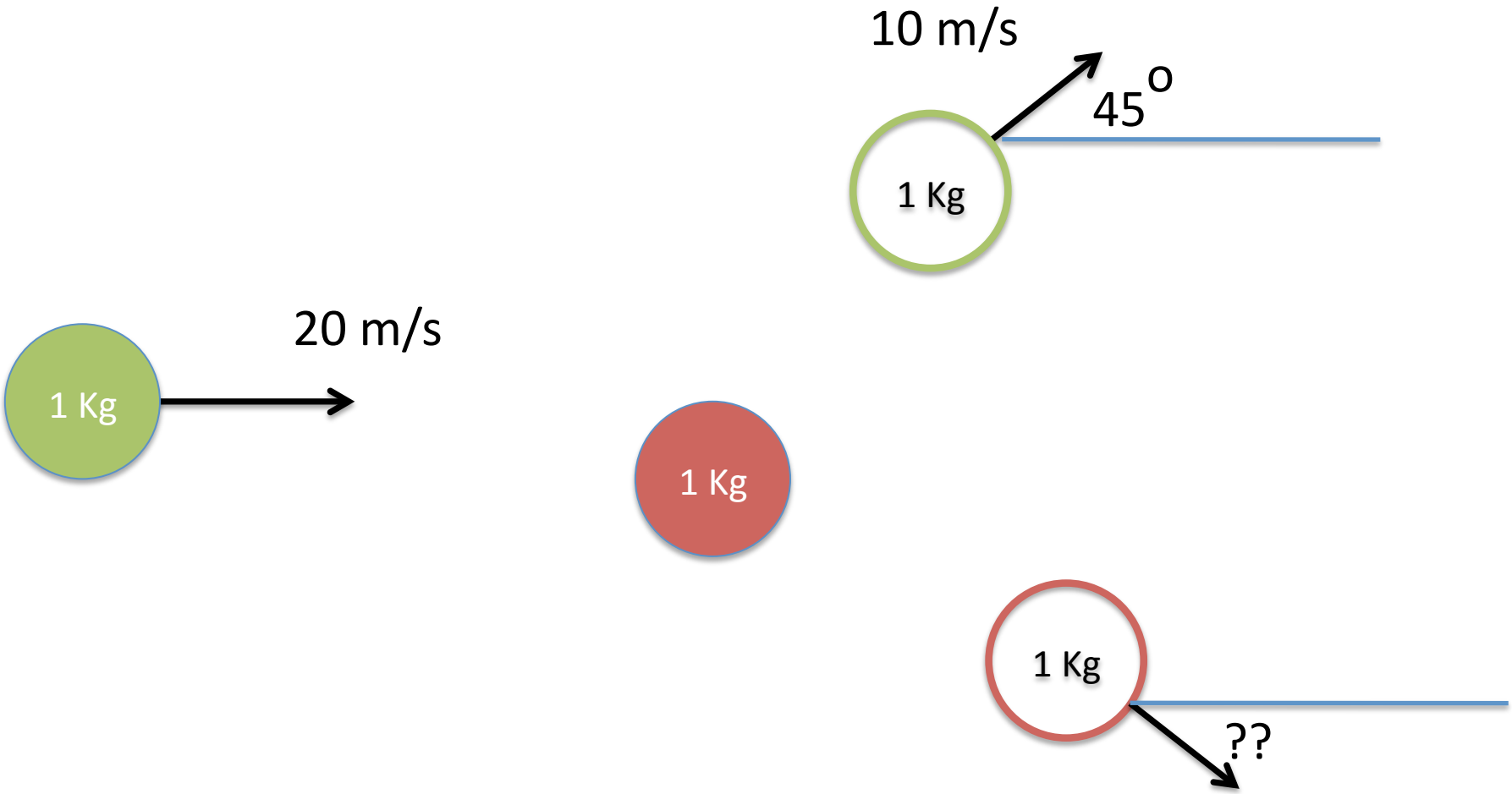
Find magnitude and direction of final velocity



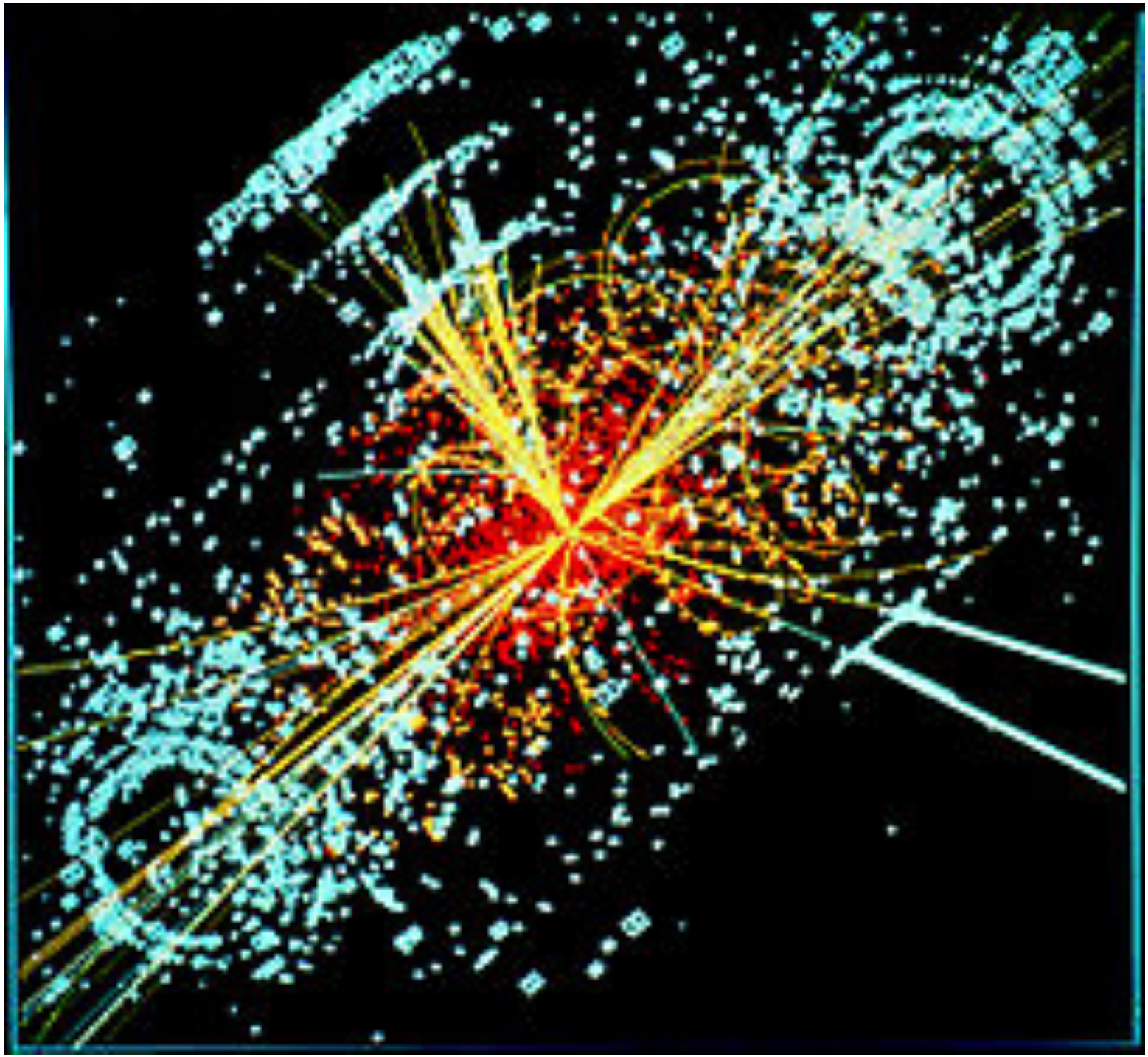





+
A
2 Kg
B
4Kg
B
4 Kg
30°
2 m/s
3 m/s
45°
A
2 Kg
+



What is the angle at which the red ball scatters ?



Higgs
Boson
simulation