Using momentum vectors

Like any vector quantity, momentum can be represented with vectors. Thus, it must obey the rules of vector addition (i.e., when the number of objects colliding is 2, we can use vectors to solve problems). David Wheeler, in his paper Whole Vectors, describes this as one of the ways he uses vectors consistently throughout the class. Since students have solved problems using vector representations of 2-d motion throughout the course, they are comfortable with solving for the sides of triangles, which makes the math consistent.

In momentum vector analysis, the momentum vector has a magnitude and direction. The magnitude is |mv|, and the direction is the direction of the velocity vector. Momentum is useful for looking at changes, which means you have to look at a phenomena before and after an event. Below we provide several examples (blatantly stolen from web-searches):

One-Dimensional Momentum

1. A trolley of mass 1.43kg is moving at 1.45 m/s when it collides with a stationary trolley, and the two move off at 0.75 m/s.

First we represent the momentum vectors before and after the collision.

Before

Moving Trolley

$\mathbf{p_m}$ = 1.43kg* 1.45 m/s

= 2.07 kg*m/s

Stationary Trolley

$\mathbf{p_s}$ = m_s kg* 0 m/s

= 0 kg*m/s

$\mathbf{p_{tot}} = \mathbf{p_m} + \mathbf{p_s}$

= 2.07 kg*m/s

After

Trolleys Together

$\mathbf{p_{tot}}$ = m_{tot} kg* 0.75 m/s

= 2.07 kg*m/s

So, $\mathbf{p_{tot}}$ = 2.07 kg*m/s

= $m_s$kg* 0.75 m/s + 1.43kg* 0.75 m/s

and then m_s = 1.33kg

Two-Dimensional Momentum

1. A red 900-kg car traveling east at 15 m/s collides with a blue 750-kg car traveling north at 20 m/s. The cars stick together. With what velocity does the wreckage move just after the collision?

First we represent the momentum vectors before and after the collision.

<u>Before</u>

Red Car

$|\mathbf{p}_r|$ = 900 kg* 15 m/s

= 13,500 kg*m/s

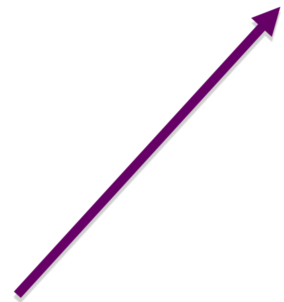
Blue Car

$|\mathbf{p}_b|$ = 750 kg* 20 m/s

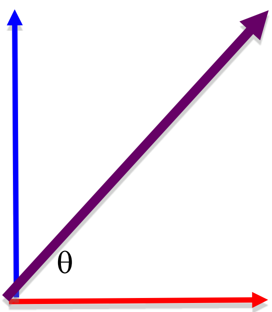
= 15,000 kg*m/s

<u>After</u>

Cars Together



$\mathbf{p}_{tot}$ = 1650 kg* $|v_f|$
= 20,180 kg*m/s



So the total p is…

$\mathbf{p}_{tot} = \mathbf{p}_{red} + \mathbf{p}_{Blue}$

= 20,180 kg*m/s

So, $\mathbf{p}_{tot}$ = 20,180 kg*m/s

And |vf| = 12.2 m/s.

To find the angle, $\cos\theta = p_{red}/p_{total}$
and $\theta = 48°$