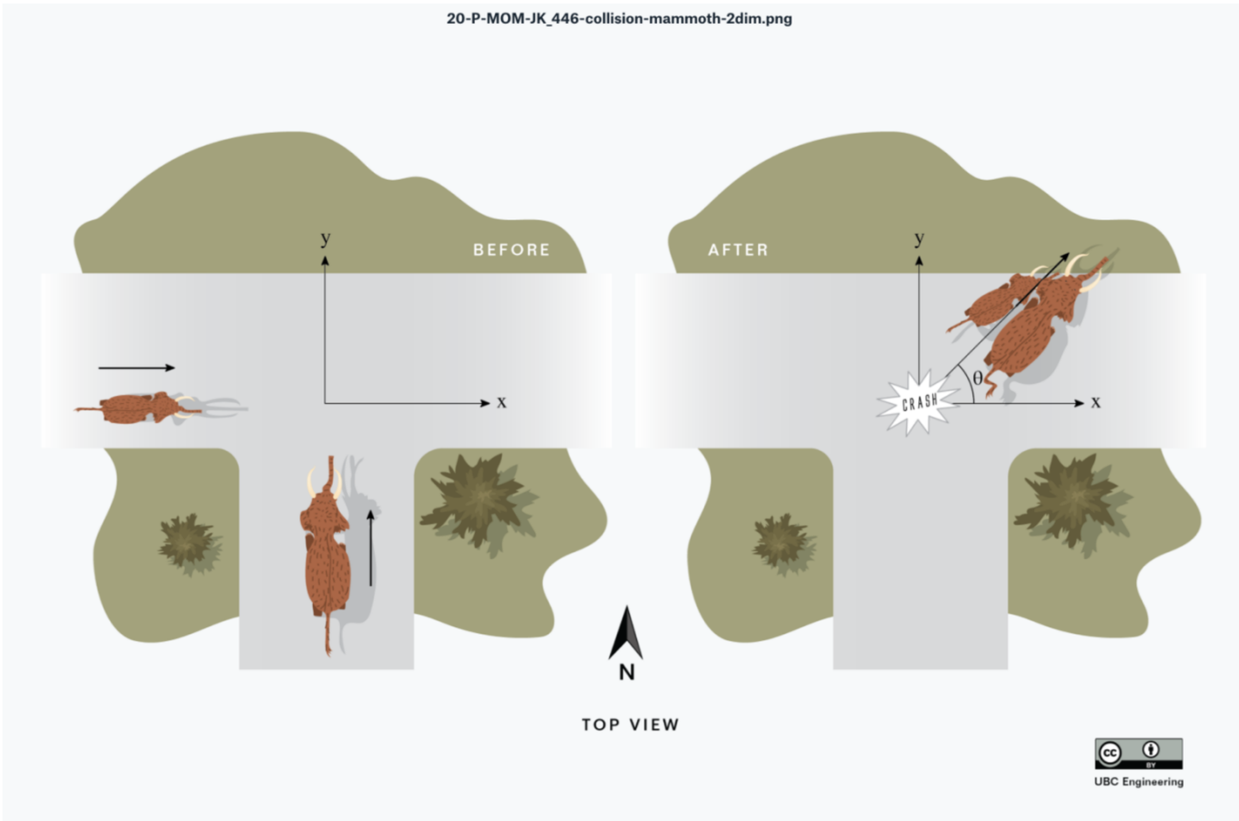
20-P-MOM-JK-445a and Mammoth-6
Collisions in two dimensions



The small mammoth A and the bigger mammoth B collided in the middle of the intersection as shown.

The small mammoth A was initially travelling to the East or in the positive x direction at a speed of 36 km/h.

Speed in m/s = (36 km/h) (1 m/s) / (3.6 km/h) = 10 m/s

The small mammoth A has a mass of 4000 kg.

The big mammoth B has a mass of 5000 kg. It is travelling in the +y direction as shown but has an unknown speed.

After the collision, they stuck together and moved off together at an angle θ = 35.0° above the x-axis as shown.

What was the ***initial*** velocity of the bigger mammoth B in metres per second if the smaller mammoth A had been traveling at 36.0 km/h in the positive x direction (as shown) before the collision? Assume that linear momentum was conserved.

Answers:

m mammoth A = 4000 kg
m mammoth B = 5000 kg

initial momentum in the east direction = $m_{\text{mammoth A}}\, v_{\text{mammoth A}}$
= 40,00 kg m/s

Momentum is conserved, so the final momentum at the angle shown is the same as the initial momentum.

$$tan\theta = \frac{m_{mammoth\ B}\, v_{mammoth\ B}}{m_{mammoth\ A}\, v_{mammoth\ A}}$$

$$|\overrightarrow{v_{mammoth\ B}}| = \frac{m_{mammoth\ A}\, v_{mammoth\ A} tan\theta}{m_{mammoth\ B}}$$

If if if you wanted to change this question to find the speed after the collision

$$|v\ after| = \frac{(m\ car)(v\ car)}{(m\ car + m\ van)\cos\theta}$$

| v after | = (m car) (v car) / (m car + m van) cos theta

Because.

total momentum before, as it is a vector is

$$\left|\overrightarrow{momentum}\right| = \sqrt{(m_{car}v_{car})^2 + (m_{van}v_{van})^2}$$

magnitude of momentum = SQRT ((m car v car) ^{2} + (m van v van) ^{2})

Tangent of the angle theta = (m van v van) / (m car v car)
Angle = INV TAN ((m van v van) / (m car v car))

Final velocity, after the collision
Angle of momentum before the collision = angle of the velocity after the collision as momentum is conserved

The car and van stick together so the
velocity of the cars after the collision = total momentum before / total mass

momentum after the collision = (m car + m van) (v after) at angle theta
momentum in the x direction after the collision
= (m car + m van) (v after) cos theta
momentum in the y direction after the collision
= (m car + m van) (v after) sin theta

But
momentum before in the x direction = (m car) (v car)

momentum before in the y direction = (m van) (v van)

Momentum is conserved and as you know the momentum in the x direction before the collision,
momentum before in the x direction = (m car) (v car)
momentum in the x direction after the collision

$$= (m\ car + m\ van)(v\ after)\cos\theta$$

$$(m\ car)(v\ car) = (m\ car + m\ van)(v\ after)\cos\theta$$

$$|v\ after| = \frac{(m\ car)(v\ car)}{(m\ car + m\ van)\cos\theta}$$

Yet the question was the speed of the van BEFORE the collision

momentum before in the y direction = (m van) (v van)
momentum in the y direction after the collision

$$= (m\ car + m\ van)(v\ after)\sin\theta$$

$$(m\ van)(v\ van) = (m\ car + m\ van)(v\ after)\sin\theta$$

$$v\ van = \frac{(m\ car + m\ van)(v\ after)\sin\theta}{m\ van}$$