Class 3-4-1B

Monday, October 17, 2022 8:42 AM

Impulse and Momentum

EF 151, Class 3-4

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Is there a campus in this country with more momentum than @UTKnoxville? I doubt it.

Go Vols!!! 🧡🤍🧡

> **UT System President Randy Boyd** @UT_President · Oct 15
> Pandemonium Reigns!! It's great to be a Tennessee Vol!

9:38 PM · Oct 15, 2022 · Twitter for iPhone

Impulse

$\Delta \tilde{p} = \bar{J}$

change in mv = Impulse

- $\vec{J} = \int_{t_1}^{t_2} \vec{F}\, dt$
- Impulse is equal to the area a force vs time graph.
- $\vec{J} = \overrightarrow{F_{avg}}\, \Delta t$

Units

$J = force * time\ [=]\ N\ s\ [=]\ \left(\frac{kg\ m}{s^2}\right) s\ [=]\ \frac{kg\ m}{s}$ m · v

$J = force * time\ [=]\ lb\ s\ [=]\ \left(\frac{slug\ ft}{s^2}\right) s\ [=]\ \frac{slug\ ft}{s}$

Momentum

- For a single object: $\vec{p} = m\,\vec{v}$
- For a system of objects: $\sum_{j=1}^{N} \vec{p_j} = \sum_{j=1}^{N} m_j\,\vec{v_j}$

<u>Units</u>

$$p = \text{mass} * \text{velocity}\ [=]\ \text{kg}\ \frac{\text{m}}{\text{s}}\ [=]\ \frac{\text{kg m}}{\text{s}}\ [=]\ \frac{\text{kg m s}}{\text{s}^2}\ [=]\ \text{N s}$$

$$p = \text{mass} * \text{velocity}\ [=]\ \text{slug}\ \frac{\text{ft}}{\text{s}}\ [=]\ \frac{\text{slug ft}}{\text{s}}\ [=]\ \frac{\text{slug ft s}}{\text{s}^2}\ [=]\ \text{lb s}$$

Equations

Impulse – Momentum Equation

$$\sum_{j=1}^{N} m_j \overrightarrow{v_{f,j}} = \sum_{j=1}^{N} m_j \overrightarrow{v_{i,j}} + \int_{t_1}^{t_2} \vec{F}\, dt$$

Conservation of Momentum Equation

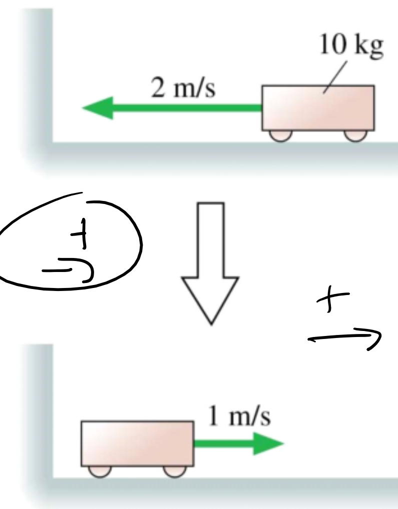
$$\sum_{j=1}^{N} m_j \overrightarrow{v_{f,j}} = \sum_{j=1}^{N} m_j \overrightarrow{v_{i,j}}$$

System with
no net external force

Change in Momentum

- The change in momentum of the car is:

A. – 20 kg m/s
B. – 10 kg m/s
C. + 10 kg m/s
D. + 30 kg m/s



$$\Delta \bar{p} = m\bar{v}_f - m\bar{v}_i$$

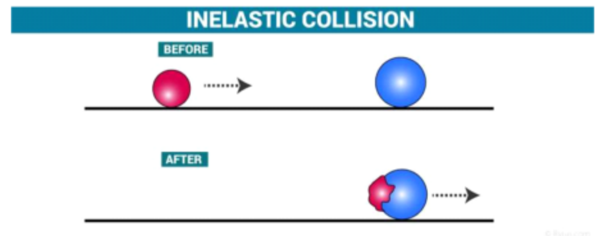
$$= 10\,kg\,(+1\,m/s) - 10\,kg\,(-2\,m/s)$$

$$10\,kg\,\frac{m}{s} + 20\,kg\,\frac{m}{s} = 30\,kg\,\frac{m}{s}$$

Collisions

- In an inelastic collision:

  A. Kinetic Energy is conserved
  B. Momentum is conserved
  C. Both are conserved
  D. Neither are conserved

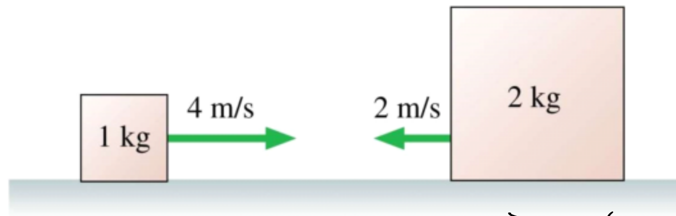


Collisions

- The two boxes are sliding along a frictionless surface. They collide and stick together. Afterward, the velocity of the two boxes is:

perfectly inelastic

A. 2 m/s to the left.
B. 1 m/s to the left.
C. 0 m/s, at rest.
D. 1 m/s to the right.



$$m_1 v_1 + m_2 v_2 = (m_1 + m_2) v'$$

$$1\,kg(4\,m/s) + 2\,kg(-2\,m/s)$$

$$4 - 4 = 0$$

Throwing a Ball

- You awake in the night to find that your living room is on fire. Your one chance to save yourself is to throw something that will hit the back of your bedroom door and close it, giving you a few seconds to escape out the window. You happen to have both a sticky ball of clay and a super-bouncy Superball next to your bed, both the same size and same mass. You've only time to throw one. Which will it be? Your life depends on making the right choice!

  A. Throw the Superball. Perfectly elastic — Bigger change in momentum
  B. Throw the ball of clay. Perfectly inelastic — Bigger impulse
  ~~C. It~~ doesn't matter. Throw either.

Practice 3-4-1

The head of a snowman has a mass of 5.6 kg and is loosely attached to the snowman. Rachel and Taylor throw various objects at the snowman's head.

We want to find the velocity of the head just after impact when we throw:

(a) a 520-gram snowball at 14 m/s which sticks to the head,

(b) a 520-gram rubber ball at 14 m/s which bounces back at 8 m/s, and

(c) a 520-gram rock at 14 m/s that goes though the head and exits at 8 m/s.

$$m_b v_b + m_h v_h^{\,0} = m_b v_b' + m_h v_h' \qquad v_h'$$

$$14\,m/s \; + \qquad = \qquad -8\,m/s$$

$$m_e v_e + m_c v_c = (m_e + m_c) v'$$

$$12\,ton\left(\frac{2000\,lb}{ton}\right)\left(\frac{1}{32.2\,ft/s^2}\right) v_e + 34\,ton\, v_c = 46\,ton\, v'$$

Practice 3-4-2

The train engines (12 tons) and their cars (34 tons) were initially separated. Somewhere down the track they couple together.

We want to find:

(a) the velocity of the coupled engines and cars given initial velocities,

(b) the velocity of the coupled engines and cars given different initial velocities,

(c) the percentage of energy lost during part (b),

$E_i = 100\,kJ$ $\quad E_{loss} = 10\,kJ$

$E_f = 90\,kJ$ $\quad \frac{10}{100}$

(d) the initial velocity of the engines if the cars were at rest, given the final velocity, and

(e) the extra weight in the cars given initial and final velocities.

Practice 3-4-3

A 75 kg Prof. Sukanek wearing ice skates stands motionless on the ice when he throws a 6 kg block with a velocity as shown.

We want to find:

(a) the horizontal component of his velocity after the throw, assuming the throw took 0.20 seconds to complete,

(b) the horizontal component of his velocity after the throw, assuming the throw took 1.60 seconds to complete, and

(c) the kinetic energy of the system after the block is released.