Announcements

- CompDay 2 on Monday! (We must labor on Labor Day!)
- Homework 2 due Monday night
  - If I haven't gotten you feedback yet on HW1, it is coming soon
- Physics Tea today!
  - Social time in Discord at 3:00
  - Talks from students about summer research start in Zoom at 3:30
- Responses: `rembold-class.ddns.net`

Today's Objectives

- Remember how conservation of momentum works
- Understand mathematically how rockets work
- Gain a conceptual feel for rocket behaviour and limitations

Q1

Two cars traveling with velocities given below collide at the position $\vec{r} = \hat{\boldsymbol{x}} + 2\hat{\boldsymbol{y}}$. Car A has a mass of 500 kg and Car B a mass of 300 kg. If the two cars stick together after the collision and no external forces are acting on the system, what is the final velocity of the resulting wreck?

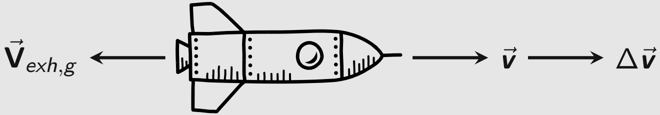
$$\vec{\boldsymbol{v}}_A = \langle 4x, z-5, y^2 \rangle \mathrm{m/s}$$
$$\vec{\boldsymbol{v}}_B = \langle xy, y, z+3 \rangle \mathrm{m/s}$$

A) $\langle 3.25, 3.875, 6.245 \rangle \mathrm{m/s}$
B) $\langle 3.25, -2.375, 3.625 \rangle \mathrm{m/s}$
C) $\langle -3.25, -3.875, 6.245 \rangle \mathrm{m/s}$
D) None of the above

MECHANICS

Q2

Imagine a rocket traveling at velocity $\vec{\boldsymbol{v}}$ relative to the ground and with total mass $m + \Delta m$. A short time (Δt) later, the rocket has expelled a mass Δm out its back end with velocity $\vec{\mathbf{V}}_{exh,g}$, where $\vec{\mathbf{V}}_{exh,g}$ is the velocity with respect to the ground. What expression best describes the total momentum of the rocket + expelled fuel now?



A) $\vec{\mathbf{p}}_{tot} = m(\vec{\boldsymbol{v}} + \Delta\vec{\boldsymbol{v}}) + \Delta m\vec{\mathbf{V}}_{exh,g}$

B) $\vec{\mathbf{p}}_{tot} = m(\vec{\boldsymbol{v}} + \Delta\vec{\boldsymbol{v}}) - \Delta m\vec{\mathbf{V}}_{exh,g}$

C) $\vec{\mathbf{p}}_{tot} = m(\vec{\boldsymbol{v}} - \Delta\vec{\boldsymbol{v}}) - \Delta m\vec{\mathbf{V}}_{exh,g}$

D) $\vec{\mathbf{p}}_{tot} = m(\vec{\boldsymbol{v}} - \Delta\vec{\boldsymbol{v}}) + \Delta m\vec{\mathbf{V}}_{exh,g}$

MECHANICS

Rocketmannnn!

Q3

Our expression is in terms of the velocity of the exhaust relative to the ground ($\vec{\mathbf{V}}_{exh,g}$). What vector expression relates the velocity of the exhaust relative to the ground to the velocity of the exhaust relative to the rocket ($\vec{\mathbf{V}}_{exh,r}$) and the velocity of the rocket relative to the ground ($\vec{\boldsymbol{v}}_{r,g}$)?

A) $\vec{\mathbf{V}}_{exh,g} = \vec{\boldsymbol{v}}_{r,g} + \vec{\mathbf{V}}_{exh,r}$

B) $\vec{\mathbf{V}}_{exh,g} = \vec{\boldsymbol{v}}_{r,g} - \vec{\mathbf{V}}_{exh,r}$

C) $\vec{\mathbf{V}}_{exh,g} = -\vec{\boldsymbol{v}}_{r,g} + \vec{\mathbf{V}}_{exh,r}$

D) $\vec{\mathbf{V}}_{exh,g} = -\vec{\boldsymbol{v}}_{r,g} - \vec{\mathbf{V}}_{exh,r}$

Rocketmannnn!

Q4

Suppose you have a rocket which has a mass when empty of 500 kg and can accept 750 kg of fuel. How much speed could you hope to gain by burning all the available fuel?

A) $0.92 v_{exh}$

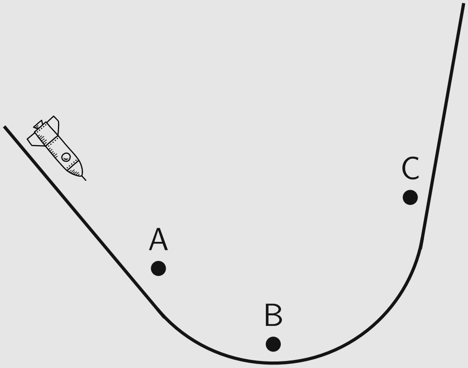
B) $1.10 v_{exh}$

C) $0.51 v_{exh}$

D) $1.96 v_{exh}$

Q5

Suppose your rocket had a small amount of fuel, which you can burn all at once in a sudden burst. The rocket is traveling through the curve shown to the right, and you have the option to decide when you want to burn your fuel. At which point should you hit the thruster to make sure you make it up the far slope as high as possible? You can assume no forces except gravity are acting on your rocket otherwise.



D: It doesn't matter.