Physics 3B Week 2: Fluid Mechanics

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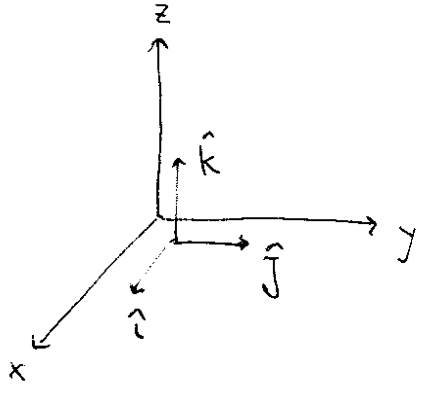
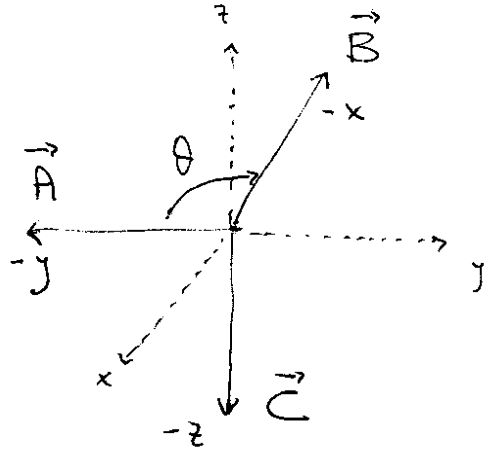
Day: Wednesday Hour: 8:00 - 12:50

1. Problem 1

Vector **A** = - 2 $\hat{j}$ and vector **B** = - 4 $\hat{i}$, calculate magnitude and direction of **C** = **A** x **B**, and draw the vectors in a Cartesian coordinate system, labeling all vectors (**A**, **B**, and **C**):



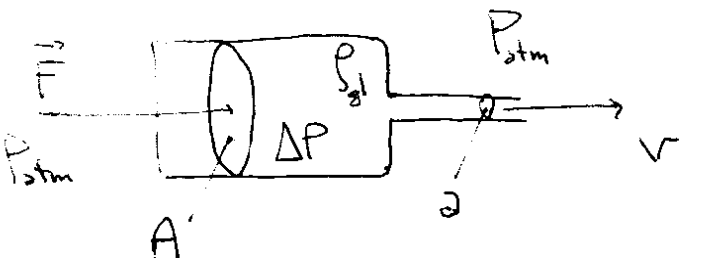


$\vec{C}$ points to the negative z-direction

$C = |A||B| \sin\theta = 2 \cdot 4 \sin 90^\circ = 8.$

2. Problem 2

A syringe contains glycerin $\rho_{glycerin} = 1.26 \times 10^3$ kg/m^3. The barrel has a cross-sectional area $A = 0.4 \times 10^{-4}$ m^2 and the needle has a cross-sectional area $a = 1.3 \times 10^{-8}$ m^2. If no force is applied, the pressure outside is the atmospheric pressure P_{atm}. However, if a force $\vec{\mathbf{F}} = 1.8$ N is applied on the plunger, what is the speed of the ejected glycerin at the needle's tip?
(Hint: sketch a picture and label all given parameters)



Pressure difference: $\Delta P = \frac{F}{A} = P_1 - P_2$

Using continuity Eq. to estimate V:

$$A v_1 = a v_2 \Rightarrow v_2 = \frac{A}{a} v_1 \simeq 3.1 \times 10^3 \, v_1$$

$$\Rightarrow v_1^2 \ll v_2^2$$

Using Bernoulli's Eq.:

$$P_1 + \underbrace{\frac{1}{2}\rho v_1^2}_{\simeq 0} + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$$

$$P_1 - P_2 = \Delta P = \frac{1}{2}\rho v_2^2$$

$$\Rightarrow v_2 = \sqrt{2\frac{\Delta P}{\rho_{gl}}} = \sqrt{2\frac{F}{A}\frac{1}{\rho_{gl}}} = \sqrt{2 \cdot \frac{(1.8)\,N}{0.4 \times 10^{-4} m^2} \cdot \frac{m^3}{1.26 \times 10^3 kg}}$$

$$\boxed{v_2 = \sqrt{71 \frac{m^2}{s^2}} \simeq 8.4 \ m/s.}$$