Physics 3B Week 2: Fluid Mechanics

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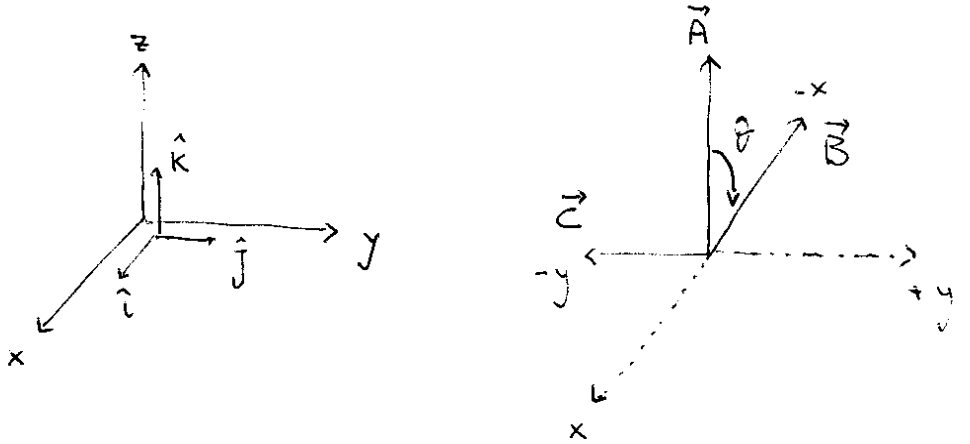
Day: Wednesday Hour: 8:00 - 12:50

1. Problem 1

Vector $\mathbf{A} = 4\,\hat{k}$ and vector $\mathbf{B} = -3\,\hat{i}$, calculate magnitude and direction of $\mathbf{C} = \mathbf{A} \times \mathbf{B}$, and draw the vectors in a Cartesian coordinate system, labeling all vectors (**A**, **B**, and **C**):

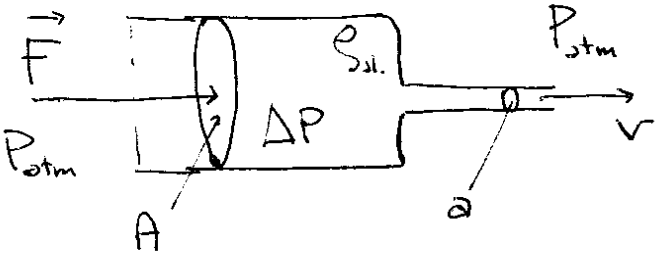


$\vec{C}$ points to the negative y-direction

$C = |A||B| \sin\theta = 4 \cdot 3 \sin 90^\circ = 12.$

2. Problem 2

A syringe contains ethyl alcohol $\rho_{alcohol} = 0.806 \times 10^3$ kg/m^3. The barrel has a cross-sectional area $A = 3.2 \times 10^{-5}$ m^2 and the needle has a cross-sectional area $a = 0.9 \times 10^{-8}$ m^2. If no force is applied, the pressure outside is the atmospheric pressure P_{atm}. However, if a force $\vec{F} = 2.1$ N is applied on the plunger, what is the speed of the ejected alcohol 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_1:

$$A V_1 = a V_2 \Rightarrow V_2 = \frac{A}{a} V_1 = 3.5 \times 10^3 V_1$$

$$\Rightarrow V_1^2 \ll V_2^2$$

Using Bernoulli's Eq.:

$$P_1 + \underbrace{\frac{1}{2}\rho V_1^2}_{\approx 0} + \rho g y_1 = P_2 + \frac{1}{2}\rho V_2^2 + \cancel{\rho g y_2}$$

$$P_1 - P_2 = \Delta P = \frac{1}{2}\rho V_2^2$$

$$\Rightarrow V_2 = \sqrt{2\frac{\Delta P}{\rho}} = \sqrt{2\frac{F}{A}\frac{1}{\rho_{alcohol}}} = \sqrt{2 \cdot \frac{(2.1)\,N}{3.2\times10^{-5}\,m^2} \cdot \frac{m^3}{0.806 \cdot 10^3\,kg}}$$

$$V_2 = \sqrt{1.63 \times 10^2 \frac{m^2}{s^2}} = 12.8\ m/s.$$