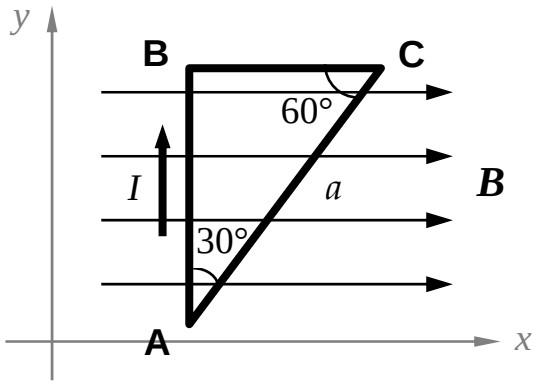
Discussion Question 8A
P212, Week 8
Magnetic Forces and Torques on Loops

A triangular loop with hypotenuse a and 30˚ - 60˚ - 90˚ angles lies in the xy plane. A constant current I circulates clockwise around the loop, and a uniform magnetic field of strength B points in the $+x$ direction.

a = 3.0 cm
B = 0.04 T
I = 5 A



(a) Calculate the **forces** on each of the three sides of the current loop (**AB**, **BC**, and **CA**), and sum them to find the **net force** on the loop. Remember that you will be adding *vectors*, so express each force in terms of its components.

(b) Inspect the directions you found for the forces on each of the three sides. These forces are clearly trying to *turn* the loop … in which direction does the resulting torque point?

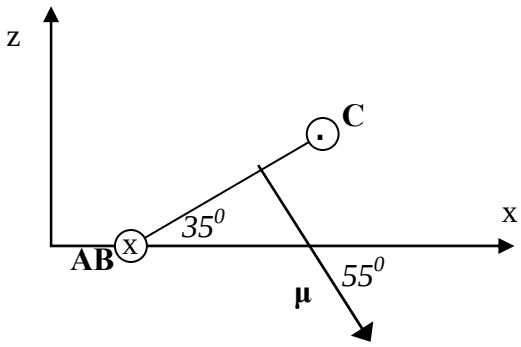
(c) What is the magnetic moment μ of the loop? Since μ is a vector, remember to specify its direction.

(d) What is the torque τ on the loop? Since τ is a vector, remember to specify its direction. Is it the same as what you found in part (b)? I hope so … and I hope you'll agree that using magnetic moments to analyze the loop is a lot easier than working with forces directly!

(e) In which direction would you orient the B field so that no torque was exerted on the loop?

(f) What is the potential energy U of the loop? Is U at its maximum or minimum possible value, or is it somewhere in between?

Now imagine that the **AB** side of the loop is fixed to a pivot, and that the loop is tilted at an angle $\theta = 35^{\circ}$ with respect to the *xy* plane. (Picture point **C** raised out of the paper to make the specified angle).



(g) Does the tilt change the magnetic moment of the loop? If so, specify the new vector **μ**.

(h) What is the torque τ on the loop in this orientation?

(i) What is the potential energy *U* of the loop in this orientation?

(j) What tilt angle θ would produce zero torque on the loop? It's important to note that there are two such equilibrium angles. One produces stable equilibrium, the other produces unstable equilibrium. Which is which?

(k) Finally, suppose the triangular loop had N turns of wire instead of just one. How would this change the quantities **μ**, **τ**, and *U*?