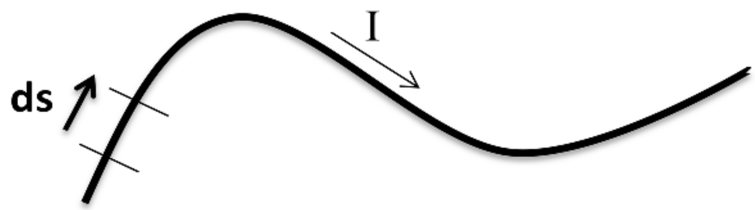
Question 1 (participation credit)



In class, we saw the result for the magnetic field of a moving point charge and the force from a magnetic field on a point charge. In this question, we'll understand how to use these to find the field from a current in a wire or the force on a current-carrying wire. Consider the little segment of wire shown above.

a) Suppose the charges in the wire have an average velocity v in the direction of the current (imagine here that they are positive charges flowing in the direction of the current). How much time dt does it take for the charges to travel the distance ds? (*answer in terms of ds and v)*

dt =

b) In this amount of time, how much charge flows into the segment? (*answer in terms of ds, v, and I, using your previous result for dt)*

Q =

c) Using your result from b), rewrite Q **v** (the moving charge in the segment times its velocity) in terms of the current I and the vector **ds**.

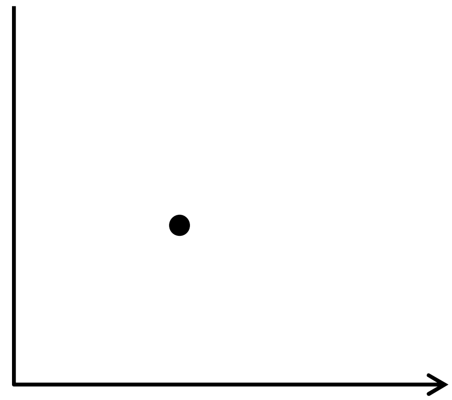
Q **v =**

Using this result, we can start with equation (32.4) for the field from a point charge to get the field from the small segment of wire shown above. To get the field from the whole wire, we need to integrate this over the wire.

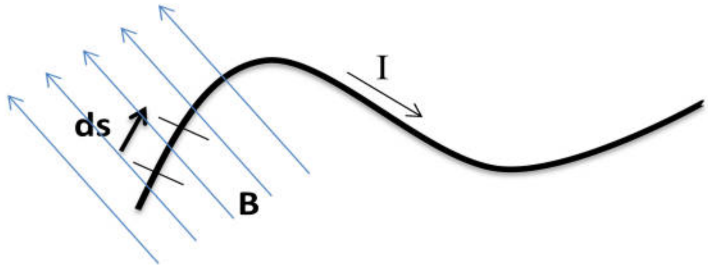
d) Read Example 32.3 (The magnetic field of a long, straight wire) to see an example of this. What is the result for the magnitude of the field at a distance d from a wire carrying current I?

Use the result to find the magnetic field 1cm away from a long straight wire carrying a current of 1A. Answer in Tesla (T):

Question 2: (to be graded)



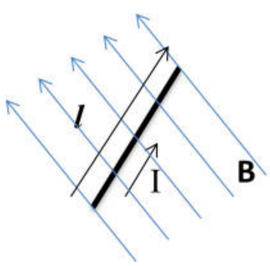
An infinitely long wire carries current in an L-shape as shown. Find the magnetic field at the point indicated, at an equal distance d from both parts of the wire.



Question 3 (participation credit): Now let's find the force on the same small segment of wire from some other magnetic field (not the one created by this segment of wire)

a) Use equation (32.17) for the force on a point charge together with your result from c) to find the force on this segment of wire in a magnetic field.

F =



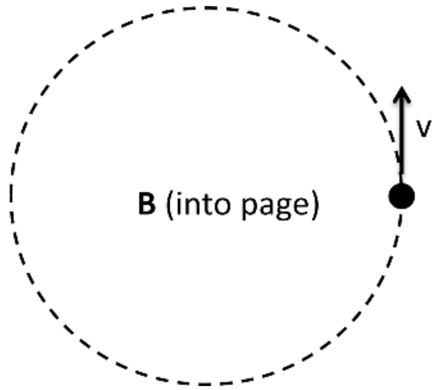
b) When there is a long straight segment of wire and the magnetic field is constant, the result above applies to the whole segment (replacing **ds** with the vector **l** along the wire with magnitude equal to the length). Make this replacement and check your result with equation 32.25 from the text.

F =

c) How much force is there on 10cm of wire carrying 1A in a magnetic field of 1T aligned perpendicular to the wire? Indicate the direction of the force on the wire if the magnetic field points into the page.

Question 4 (participation credit):

Charged particles traveling perpendicular to a constant magnetic field move in circular trajectories.



a) Find an expression for the radius of the circle, clearly explaining the logic. Answer in terms of q, B, v, and m, the mass of the particle.

b) If the velocity increases, what happens to the period of the orbit?

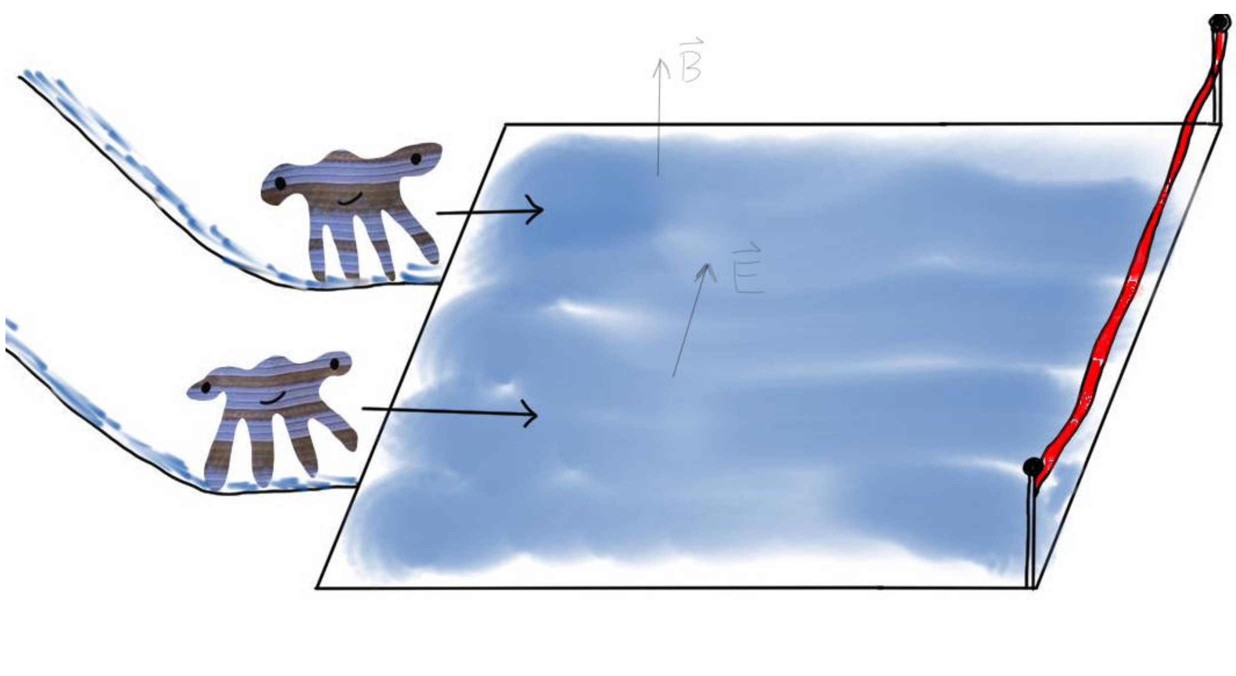
Question 5: Plankton racing!

One Saturday morning at the Marine Invertibrate Racing and Electromagnetism Society, Abigail and Patrick are racing two closely related species of zooplankton (one with a blue/black colouration and the other with a white/gold colouration) through a track with some electromagnetic features. At the end of the race, the two plankton go down approximately frictionless electrically charged slides and then slide across an approximately frictionless horizontal wet surface. The two plankton reach the bottom of the slides at the same time with the blue/black plankton travelling at 1m/s and the white/gold plankton traveling at 2m/s towards the finish line, 1m away.

If each plankton has mass $1/(4\pi) \times 10^{-5}$kg and picks up $+10^{-5}$ Coulombs of charge going down the slide, and if we have uniform electric and magnetic fields of E = 1 N/C (to the left) and B = 1 T (up) above the horizontal surface, who will win: blue/black or white/gold?

Sketch the trajectories of the two plankton.

(*Hint: you can use Euler's method if necessary, though it is possible to solve the problem without.)*



Hints for question 5:

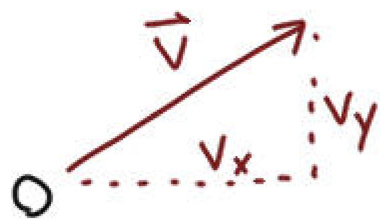
This problem is very similar to the problem of finding trajectories with drag that we did in first term. The basic steps are the usual ones for all dynamics problems.

We want to use Newton's Second Law to come up with equations that determine the motion:

$dv_x/dt = F_x/m$
$dv_y/dt = F_y/m$

where the forces here at any time are going to depend on what the the velocity is at that time.

To find expressions for the forces on the right hand side, it's useful to draw a force diagram (e.g. starting from a picture like the one at the right). Here, we've included both components of velocity, since we don't know that the object will always be moving in the x direction only.



When writing down the components of the magnetic force, you should be able to express them entirely in terms of the velocity components (together with q and B). Make sure to check the signs in your final expression to see that they are consistent with your picture.

Once you have these equations of motion, we can either try to solve them directly (they are a system of two differential equation), or use Euler's method.