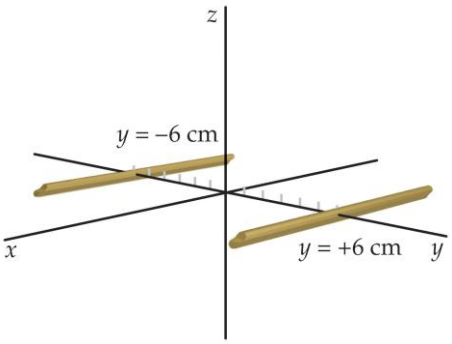
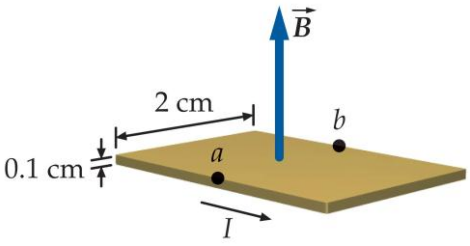
PHYS1022 Electricity and Magnetism

Problem Sheet 8 - Workshop

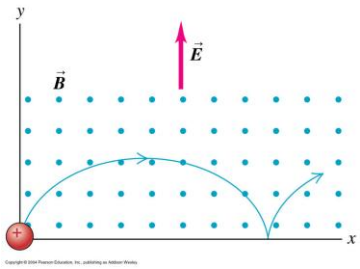
1. The figure shows two long straight wires in the *xy* plane and parallel to the *x* axis. The current in each wire is 20 A. Find the magnitude of the force per unit length exerted by one wire on the other.



2. A metal strip 2 cm wide and 0.1 cm thick carries a current of 20 A in a uniform magnetic field of 2 T, as shown in the figure. The Hall voltage is measured to be 4.27 μV.
   (a) Calculate the drift velocity of the electrons in the strip.
   (b) Find the number density of the charge carriers in the strip.
   (c) Is point *a* or point *b* at the higher potential?



3. A particle with mass *m* and positive charge *q* starts from rest at the origin shown in the figure. There is a uniform electric field *E* in the +*y*-direction and a uniform magnetic field *B* directed out of the page. The path of the particle is a cycloid whose radius of curvature at the top of the cycloid is twice the *y*-coordinate at that level.



   (a) Explain why the path has this general shape and why it is repetitive.

   (b) Prove that the speed at any point is equal to $\sqrt{\frac{2qEy}{m}}$. (Use energy conservation.)

   (c) Applying Newton's second law at the top point and taking as given that the radius of curvature here equals 2*y*, prove that the speed at this point is 2*E*/*B*.

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Problem Sheet 7 - tutorials

1. At any point in space, the electric field $\underline{E}$ is defined to be in the direction of the electric force on a positively charged particle at that point. Why not define the magnetic field $\underline{B}$ to be in the direction of the magnetic force $\underline{F}$ on a moving, positively charged particle?

2. A charged particle moves through a region of space with constant velocity (magnitude and direction). If the external magnetic field is zero in this region, can you conclude that the external electric field in the region is also zero? Explain. If the external electric field is zero in the region, can you conclude that the external magnetic field in the region is also zero?

3. An electron from the sun with a speed of 1×10^7 m/s enters the earth's magnetic field high above the equator where the magnetic field is 4×10^{-7} T. The electron moves nearly in a circle, except for a small drift along the direction of the earth's magnetic field that will take the electron towards the north pole. What is the radius of the circular motion? Derive the equation that you use.

4. A beam of protons moves along the x-axis in the positive x direction with a speed of 12.4 km/s through a region of crossed fields balanced for zero deflection.
   (a) If there is a magnetic field of magnitude 0.85 T in the positive y direction, find the magnitude and direction of the electric field.
   (b) Would electrons of the same velocity be deflected by these fields? If so, in what direction?