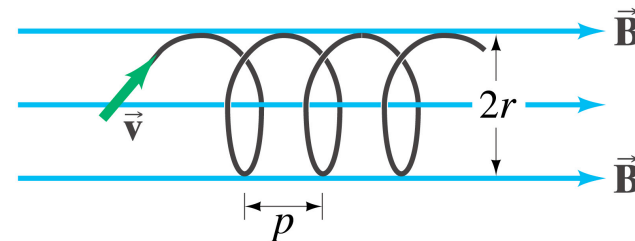
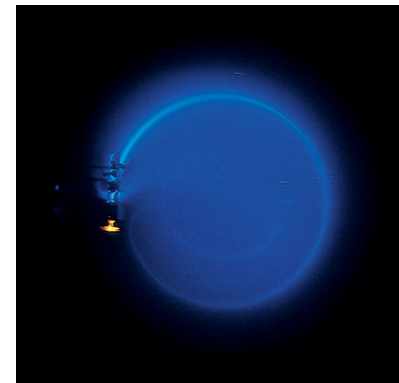


1. An electron enters a uniform magnetic field of 0.23 T at a 45° angle to Determine the radius r and pitch p (distance between loops as shown below) of the electron's helical path assuming its speed is $3.0 \times 10^6\text{ m/s}$.



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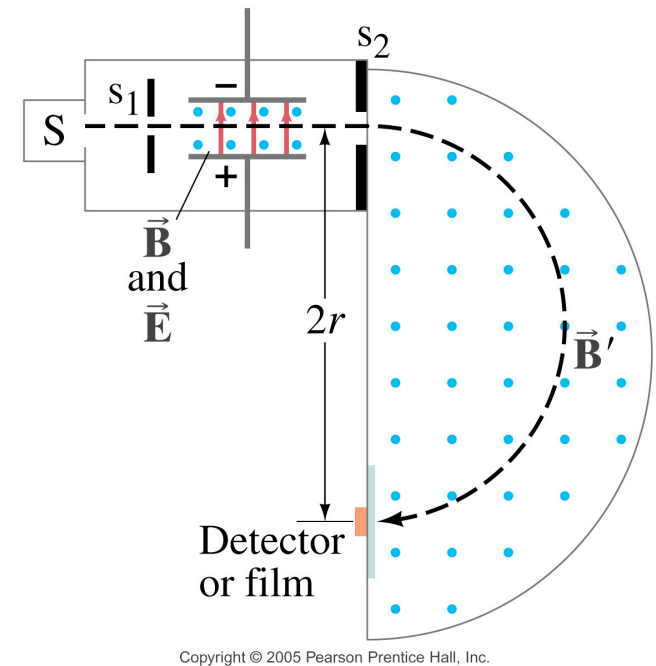
2. Suppose that electrons are accelerated from rest through a potential difference of 350 V and the electrons travel along a curved path due to a magnetic force exerted on them. The radius of the path is measured to be 7.5 cm .
- What is the velocity of the electrons as they leave the accelerator?
 - What is the magnitude of the magnetic field, assumed to be perpendicular to the beam?
 - What is the angular velocity of the electrons?
 - What is the period of orbit of the electrons?



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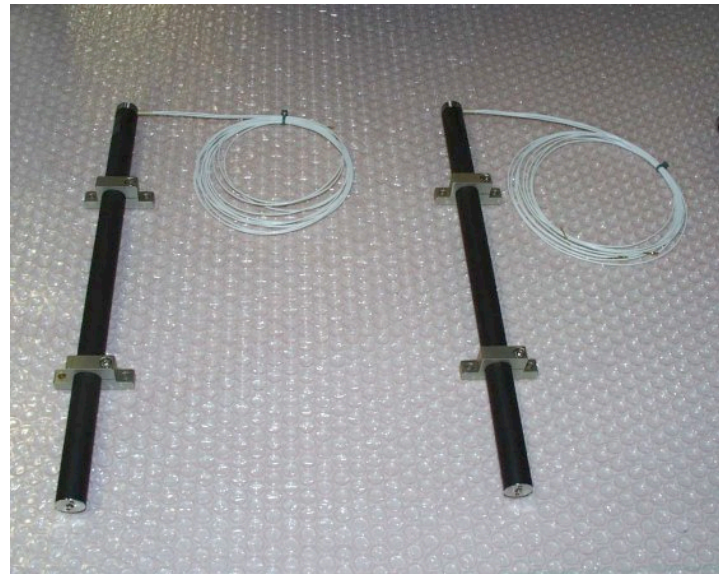
3. A “mass” spectrometer is constructed as shown on the right. A source of particles is produced at source S and proceed through slit S_1 . Suppose that the source is radioactive radium (${}^{226}_{88}\text{Ra} \rightarrow {}^{222}_{86}\text{Rn} + {}^4_2\text{He}$) and that alpha particles are ejected from the nucleus in the decay of this element. The alpha particles enter a region with crossed electric and magnetic fields.

- What is the velocity of the ions that approach slit S_2 if the electric field has a magnitude of 720 N/C and the magnetic field has a magnitude of 0.2 T?
- Where will the alpha particle hit the detector?
- Suppose that we have radioactive carbon (${}^{14}_6\text{C} \rightarrow {}^{14}_7\text{N} + {}^0_{-1}e^-$) that is a beta emitter. A beta particle is an electron produced in the nucleus as a result of the disintegration of a neutron. What will the velocity of the electron be when it hits slit S_2 ?
- Where will the beta particle hit the detector?



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4. Many satellites use coils of wire called *torquers* to adjust their orientation. These devices interact with the Earth's magnetic field to create a torque on the spacecraft in any one of three dimensions. The advantage of this type of attitude (orientation) control is that it uses solar generated electricity and does not require any fuel. Suppose that the Earth's magnetic field is $3.0 \times 10^{-5} \text{ T}$ and a coil of wire having a diameter of 4.0 m and 500 turns is used in a satellite where a current of 46 mA passes through the coil.
- a. What is the maximum torque on the wire?
- b. If the *torquer* requires 1.3 W of power to run, how large of a potential difference is needed to operate this *torquer*?



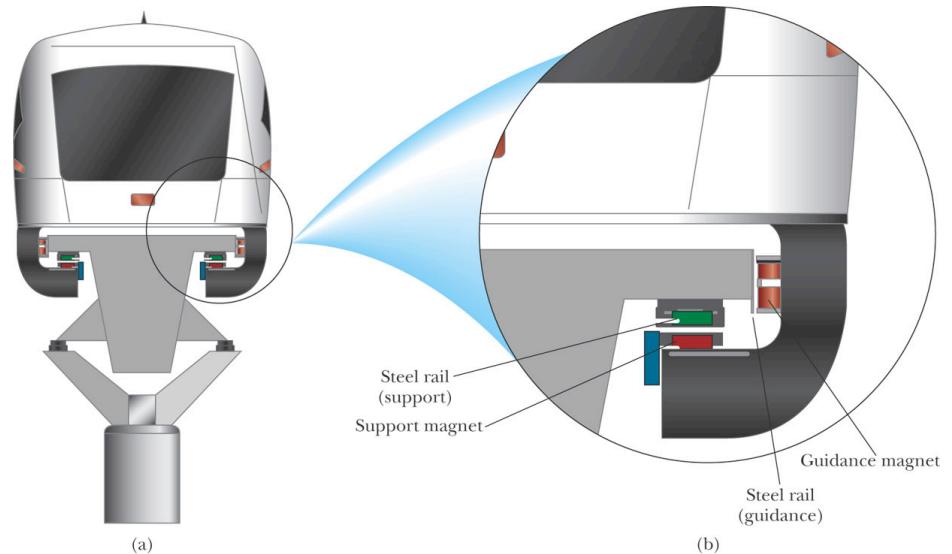
<http://www.smad.com/ie/ieframessr3.html>

5. *Magnetic levitation of a train* - The following represents a crude model for levitating a commercial transportation vehicle. Suppose the levitation is achieved by mounting small electrically charged spheres below the vehicle. The spheres pass through a magnetic field established by permanent magnets placed along the track. Let us assume that the permanent magnets produce a uniform magnetic field of 0.1 T at the location of the spheres and that an electronic control system maintains a charge of $1 \mu\text{C}$ on each sphere. The vehicle has a mass of $5 \times 10^4 \text{ kg}$ and travels at a speed of 400 km/h . How many charged spheres are required to support the weight of the vehicle at this speed? Is this practical?

6. Data for the *Transrapid maglev system* show that the input electric power required to operate the vehicle is on the order of 102 kW .
- Assume that the *Transrapid* vehicle moves at 400 km/h . Approximately how much energy, in joules, is used for each mile of travel for the vehicle?
 - Calculate the energy per mile used by an automobile that achieves 20 mi/gal . The energy available from gasoline is approximately 40 MJ/kg , a typical automobile engine efficiency is 20% , and the density of gasoline is 754 kg/m^3 .
 - Considering 1 passenger in the automobile and 100 on the *Transrapid* vehicle, the energy per mile necessary for each passenger in the *Transrapid* is what fraction of that for an automobile?



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7. A current balance is a device that has two rigid wires carrying the same current in opposite directions. The bottom wire is fixed and the other one is attached in such a way that it can pivot in response to a force from the second wire. First the pivot is adjusted so the top wire is in equilibrium with no current flowing, then the current is turned on. By adding external weight to the top wire it can be kept at its equilibrium separation distance and the magnetic force between the wires can be determined.
- a. What is the magnitude and direction of the B field produced at the upper wire, by the bottom wire?
 - b. What is the direction of the magnetic force on the upper wire due to the B field created due to current flowing in the bottom wire?
 - c. What mass is needed to balance the apparatus if the wires are 40cm long and the current flow is 10A? Assume that you want an equilibrium separation of 0.5cm.

8. *Electromagnetic Rail guns* have been suggested for launching projectiles into space without chemical rockets and for ground-to-air antimissile weapons of war. A tabletop model rail gun consists of two long, parallel, horizontal rails 3.50 cm apart, bridged by a bar BD of mass 3.00 g . The bar is originally at rest at the midpoint of the rails and is free to slide without friction. When the switch is closed, electric current is quickly established in the circuit $ABCDEA$. The rails and bar have low electric resistance, and the current is limited to a constant 24.0 A by the power supply.
- Find the magnitude of the magnetic field 1.75 cm from a single very long, straight wire carrying current 24.0 A .
 - Find the magnitude and direction of the magnetic field at point C in the diagram, the midpoint of the bar, immediately after the switch is closed.
 - At other points along the bar BD , the field is in the same direction as at point C but is larger in magnitude. Assume that the average effective magnetic field along BD is five times larger than the field at C . With this assumption, find the magnitude and direction of the force on the bar.
 - Find the acceleration of the bar when it is in motion.
 - Does the bar move with constant acceleration?
 - Find the velocity of the bar after it has traveled 130 cm to the end of the rails.

