**1993 – 20.**  The circuit diagram at right shows a battery with internal resistance of 4.0 Ω connected to a 36 Ω resistor in series.  The current in the 36 Ω  resistor is .3 Amps.  What is the emf of the battery?
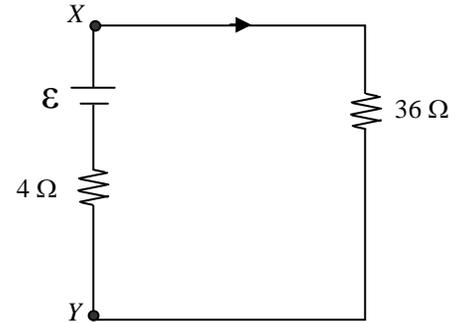
  a.  1.2 V
  b.  6.0 V
  c.  10.8 V
  d.  12.0 V
  e.  13.2 V

**1993 – 21.**  What is the potential difference across the terminals $X$ and $Y$ of the battery?

  a.  1.2 V
  b.  6.0 V
  c.  10.8 V
  d.  12.0 V
  e.  13.2 V

**1974 – 59.**  A positively charged particle moves in the positive $x$ direction in a region of uniform magnetic field $B$ directed into the page as shown at right.  The resultant force on the particle can be made equal to zero by the application of a uniform electric field in the . . .
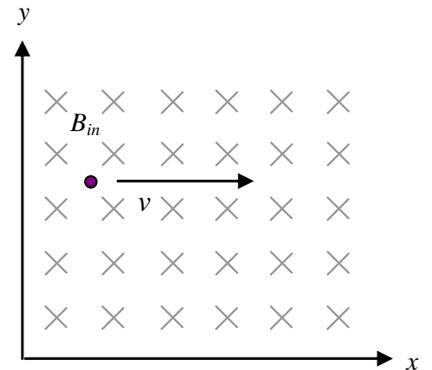
  a.  $+ y$ direction
  b.  $- y$ direction
  c.  $+ x$ direction
  d.  $- x$ direction
  e.  direction perpendicular to and out of the page

**1984 – 29.**  The figure below shows a rectangular loop of wire of width $l$ and resistance $R$.  One end of the loop is in a uniform magnetic field of strength $B$ at right angles to the plane of the loop.  The loop is pulled to the right at a constant speed $v$.  What are the magnitude and direction of the induced current in the loop?

|  | Magnitude | Direction |
|---|---|---|
| a. | $B{\cdot}l{\cdot}v{\cdot}R$ | Clockwise |
| b. | $B{\cdot}l{\cdot}v{\cdot}R$ | Counterclockwise |
| c. | $\dfrac{B{\cdot}l{\cdot}v}{R}$ | Clockwise |
| d. | $\dfrac{B{\cdot}l{\cdot}v}{R}$ | Counterclockwise |
| e. | 0 | Undefined |
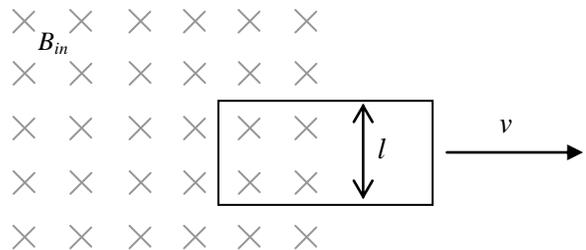
**1996 – 4.  A student is provided with a 12.0 V battery of negligible internal resistance and four resistors with the following resistances:  100 Ω, 30 Ω, 20 Ω, and 10 Ω.  The student also has plenty of wire of negligible resistance available to make connections as desired.**

(a)  Using all of these components, draw a circuit diagram in which each resistor has nonzero current flowing through it, but in which the current from the battery is as small as possible.

(b)  Using all of these components, draw a circuit diagram in which each resistor has nonzero current flowing through it, but in which the current from the battery is as large as possible (without short circuiting the battery.)

100 Ω

20 Ω     30 Ω

12 V

10 Ω
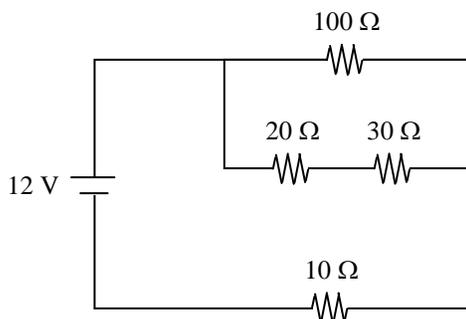
**The battery and resistors are now connected in the circuit shown above.**

(c)  Determine the following for this circuit.
      i.  The current in the 10 Ω resistor.
      ii.  The total power consumption of the circuit.

(d)  Assuming that the current remains constant, how long will it take to provide a total of 10 kJ of electrical energy to the circuit?

Proton Beam

Region of
Field *B*

*y*

*x*

(Positive *z*
out of page)
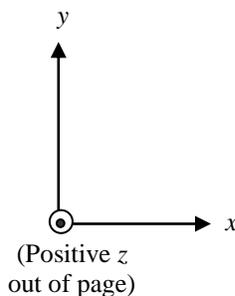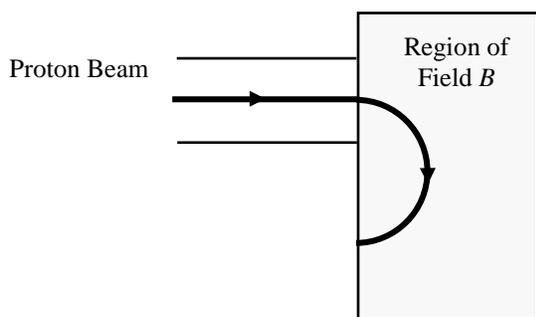
**1994 – 4.  In a linear accelerator, protons are accelerated from rest through a potential difference to a speed of approximately 3.1 x 10$^6$ m/s.  The resulting proton beam produces a current of 2.0 x 10$^{-6}$ A.**

(a)  Determine the potential difference through which the protons were accelerated.

(b)  If the beam is stopped in a target, determine the amount of thermal energy that is produced in the target in one minute.

(c)  Determine the magnitude of the field that is required to cause an arc of radius .10 m.

(d)  What is the direction of the magnetic field relative to the axes shown above on the right?
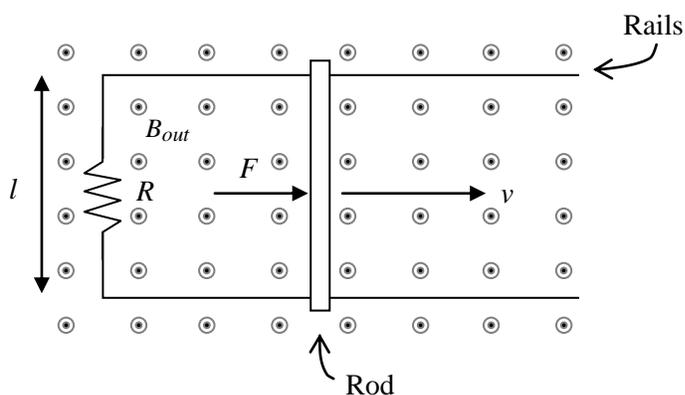
**1994 – 6. A force *F* is applied to a conducting rod so that the rod slides with constant speed *v* over a frictionless pair of parallel conducting rails that are separated by a distance *l*. The rod and rails have negligible resistance, but the rails are connected by a resistance *R*, as shown above. There is a uniform magnetic field *B* perpendicular to and directed out of the plane of the paper.**

(a) On the following diagram, indicate the direction of the induced current in the resistor.
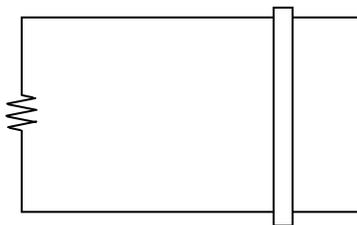


**Determine expressions for the following in terms of *v*, *B*, *l*, and *R*.**

(b) The induced emf in the rod.
(c) The electric field in the rod.
(d) The magnitude of the induced current in the resistor *R*.
(e) The power dissipated in the resistor as the rod moves in the magnetic field.
(f) The magnitude of the external force *F* applied to the rod to keep it moving with constant speed *v*.