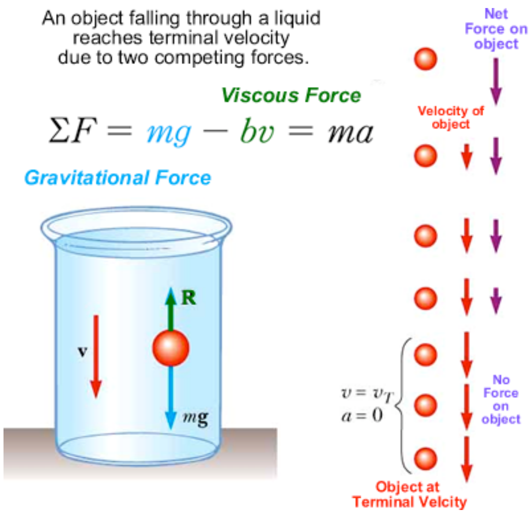
A Mechanical Analog



Sum of the Forces

$$\Sigma F = mg - bv = ma$$

Solve for the acceleration

$$g - \frac{b}{m}v = a = \frac{dv}{dt}$$

Separate Variables

$$\frac{dv}{g - \frac{b}{m}v} = dt$$

$$\int_0^v \frac{dv}{g - \frac{b}{m}v} = \int_0^t dt$$

Integrate

2 pts

$$(g - \frac{b}{m}v)/g = e^{-bt/m}$$

Solve for Velocity

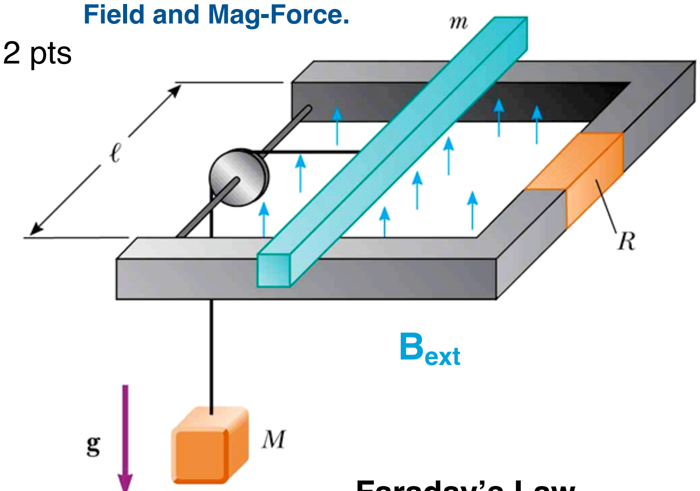
2 pts

Physics 196 Chapter 31 Problem 66

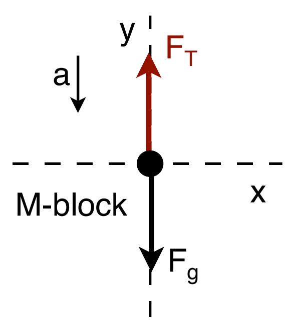
The **bar** of mass *m* in is pulled horizontally across parallel rails by a massless string that passes over an ideal pulley and is attached to a suspended **mass *M*.** The uniform magnetic field has a magnitude *B,* and the distance between the rails is ℓ. The rails are connected at one end by a load resistor *R.* Derive an expression that gives the horizontal speed of the bar as a function of time.

Draw Induced current, Magnetic Field and Mag-Force.

2 pts



FreeBody Diagrams



3 pts

Faraday's Law

1 pts

The *magnetic flux is changing* through the area bounded by the bar and the rails. According to **Faraday's Law** a *changing magnetic flux* will induce an **emf** in the circuit which will then produce a **current** which will then produce an **induced magnetic field** that will **oppose** the *changing magnetic flux*.

Looking at the diagram, the direction of the induced current is counterclockwise. This will produce a **magnetic field** that will add to the external magnetic field through the circuit. Since the arrows are pointing in the same direction there is a *repulsion* between the **induced** and the **external** magnetic fields to the right.

Since the magnetic flux is decreasing through the circuit the induced magnetic field will produce a force on the bar that will **oppose** this change.

Sum of the Forces

$$\Sigma F_y = F_T - F_g = -Ma_y$$

1 pts

$$a_y = a_x$$

Falling Mass

$$F_T = mg - Ma$$

Sliding Bar

1 pts

We need to find the induced magnetic force

$$\Phi_B = BA\cos\theta$$

$$I_{ind} = \frac{\varepsilon}{R} =$$

2 pts

$$F_B = BI_{ind}L =$$

2 pts

Set eq's equal and solve for the acceleration

2 pts

$$\frac{mg - F_B}{M + m} = a$$

$$\frac{mg - F_B}{M + m} = \frac{dv}{dt}$$

Plug in F_B and simplify.

2 pts

Let's reduce our stress and set

$$\alpha = \frac{mg}{M + m}$$

$$\beta = \frac{B^2 l^2}{R(M + m)}$$

Separate Variables

2 pts

$$\int_0^v \frac{dv}{\alpha - \beta v} = \int_0^t dt$$

Integrate

2 pts

$$(\alpha - \beta v)/\alpha = e^{-\beta t}$$

Solve for Velocity

2 pts

Draw the graph of the velocity wrt time. What is the terminal velocity? Show on the graph the velocity at e^{-2}?

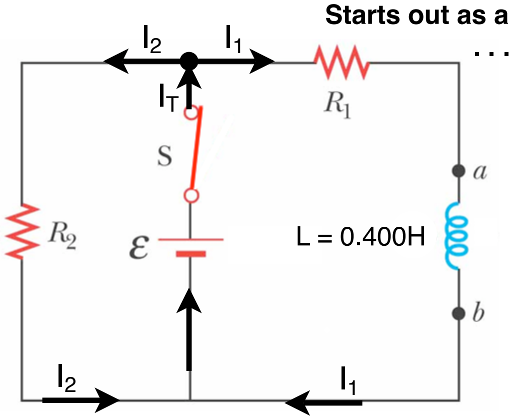
4 pts

Physics 196 Chapter 32 Problem 71

The emf = 14.0 V, R_1 = 2.80 kohms, and R_2 = 5.00 kohms. The switch is closed for t < 0, and steady-state conditions are established. The switch is now thrown open at t = 0. (a) Find the initial voltage emf_0 across L just after t = 0. Which end of the coil is at the higher potential: a or b? (b) Make freehand graphs of the currents in R_1 and in R_2 as a function of time. Show values before and after t = 0. (c) How long after t = 0 does the current in R_2 have the value 2.00 mA? (30 points)

Starts out as a

. . .Parallel Circuit

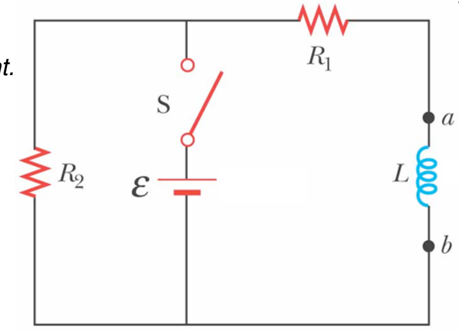


Current is constant

. . .then ends as a ____________________

Show which end of the inductor is at a higher potential. *4 pts*

Show the initial direction of the current.



After the switch is opened use Kirchhoff's Voltage Sum Rule

What is the induced emf over the inductor?

$$I(R_1 + R_2) + \boxed{} = 0$$

Is the initial current is increasing or decreasing? *3 pts*

a. The switch is closed for a long time so the current in both branches has reached a constant value.

b. The voltage over the inductor is zero because the current has stopped changing. No change in current no 'back emf'.

c. A constant Magnetic Field has been established in the coil.

Find the ***steady state current*** *for the left and right loops when the switch is closed using Kirchhoff's Current Sum Rule.*

$$I_T = I_1 + I_2$$

$$I_T = \frac{\varepsilon}{R_1}(1 - e^{\frac{-R_2 t}{L}}) + \frac{\varepsilon}{R_2}$$

Derive the current wrt time when the switch is closed.

symbolically *6 pts*

a. The power source is disconnected. Initially the current is CW / CCW thru the inductor.

b. Because the current is ____________ the coil reacts by inducing a ____________emf.

c. The current through the inductor will begin to ____________ in magnitude but continue in the ____________ direction. The current in the left loop ____________ direction.

d. ____________ is at a higher potential because the coil is trying to keep the current from falling to zero.

Find the Steady-state current in the ***left*** *and* ***right*** *loop*

plug in values *4 pts*

$$I = \frac{\varepsilon}{R_2 + R_1}(e^{\frac{-(R_2+R_1)}{L}t})$$

$$I_f = I_O e^{\frac{-(R_2+R_1)}{L}t}$$

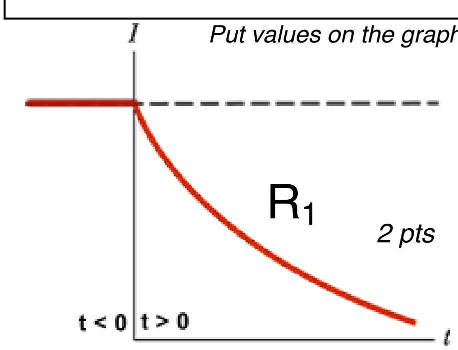
Find the initial emf over the Inductor when the switch is opened? Use Kirchhoff's Voltage Sum Rule. *2 pts*

symbolically

plug in values

2 pts

Put values on the graphs below.

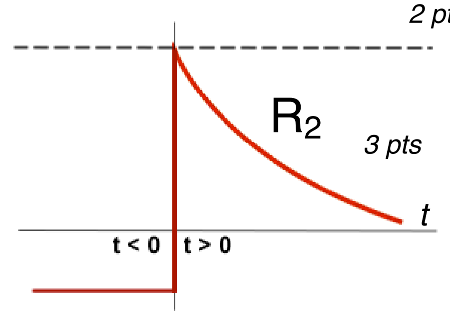


2 pts

What is the time required for current to fall to 2.00mA?

plug in values *2 pts*

Put values on the graphs below.



3 pts