

Mississippi State University
Department of Physics and Astronomy
PH 2223 Lab

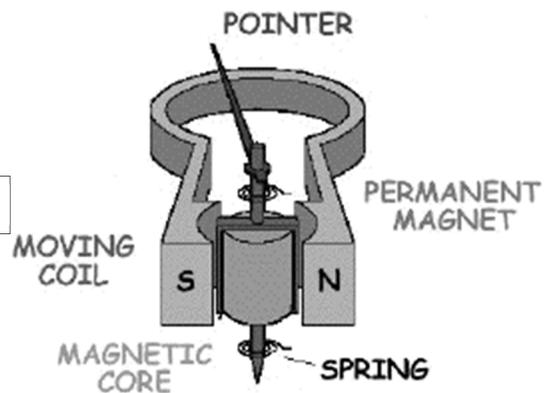
Construction of Voltmeter and Ammeter from a Galvanometer

The first voltmeters and ammeters were made up of galvanometers. In this age of digital meters, it is fun to study how those old instruments worked. So we are going to work out the relations at work behind their workings.

Draw small diagrams to illustrate how a resistor is placed with a galvanometer to make the setup a voltmeter and/or an ammeter. How do you think the meter should respond to the change in quantity it is measuring? (You may talk in terms of derivatives or degree of the relation).

Familiarize yourself with *Equation 27.19* (P.933; Sears and Zemansky's University Physics, Ed.12) and the fact that if a spring is wound up the restoring torque is proportional to the angle of twist. Therefore $\tau_{spring} = k\theta$.

Fig.1: Schematic diagrams of a mechanical Galvanometer



The magnetic field \mathbf{B} , provided by the permanent magnet is radial so $\sin \phi = 1$. Also consider the number of windings is N .

1. If current \mathbf{I} flows through the rectangular ($l \times b$) coil in between the permanent magnet, what is the torque created?
 (Hint: The magnetic field is along the breadth b of the coil, so torque by this part is nullified due to the sine term being 0. Also remember torque, $\tau = \mathbf{F} \times \mathbf{r}$ where \mathbf{F} is the force acting on at a distance r from the axis of rotation. The only part of the coil that leads to a torque are the vertical l part of coil.)
2. Equate the torque obtained in step 1 to the torque due to spring. This just means that the magnetic torque (caused due to \mathbf{I}) is matched by the spring balancing them out and thereby cancelling any further motion. The spring comes to equilibrium at this point.
3. Rearrange the terms to express a relation of θ in terms of \mathbf{I} . What do you observe the relation to be (Linear/ quadratic/ cubic...?)

Challenge

From the diagram you drew involving the galvanometer and resistors derive an expression for V_{max} and I_{max} (that can be put into their respective circuits) for both your voltmeter and ammeter setups in terms of resistor included, resistor of the galvanometer and the maximum V_{gal} or I_{gal} that the galvanometer can handle.