March 27, 2013

Physics 132

Prof. E. F. Redish

- **Theme Music:** Fleetwood Mac
  *Silver Springs*

- **Cartoon:** Pat Brady
  *Rose is Rose*

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Quiz 6

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**Avg. = 5.6**

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Prof. E. F. Redish
Foothold ideas:
Kirchhoff’s principles

1. Flow rule: The total amount of current flowing into any volume in an electrical network equals the amount flowing out.
2. Ohm’s law: in a resistor, $\Delta V = IR$
3. Loop rule: Following around any loop in an electrical network the potential has to come back to the same value (sum of drops = sum of rises).
   - The Constant Potential Corollary: Along any part of a circuit with 0 resistance, $\Delta V = 0$, i.e., $V$ is constant.

Foothold ideas:
Harmonic oscillation

- There is an equilibrium (balance) point where the mass can stay without moving.
- Whichever way the mass moves, the force is in the direction of pushing it back to its equilibrium position.
- When it gets back to its equilibrium, it’s still moving so it overshoots.
Model system: Mass on a Spring

- Consider a cart of mass $m$ attached to a light (mass of spring $\ll m$) spring.
- Choose the coordinate system so that when the cart is at 0 the spring is at its rest length.
- Recall the properties of a (nice) spring.
  - When it is pulled or pushed on both ends it changes its length.

$$T = k\Delta l$$

Analyzing the forces: cart & spring

- FBD: What are the forces acting on the cart?

$T_{s\to c}$
$N_{t\to c}$
$W_{e\to c}$
Doing the Math: The Equation of Motion

- The N2 equation for the cart is

\[ a = \frac{F_{\text{net}}}{m} = -\frac{kx}{m} = -\left(\frac{k}{m}\right)x \]

- What kind of a quantity is \( \frac{k}{m} \)?

\[
\begin{bmatrix}
  k \\
  m
\end{bmatrix} = \]

Mathematical structure

- Express \( a = \frac{F_{\text{net}}}{m} \) in terms of derivatives.

\[ \frac{d^2x}{dt^2} = -\omega_0^2 x \]

- Except for the constant, this is like having a functions that is its own second derivative.

\[ \frac{d^2f}{dt^2} = -f \]

- In calculus, we learn that \( \sin(t) \) and \( \cos(t) \) work like this. How about: \( x = \cos t \)?