

# Applied Physics

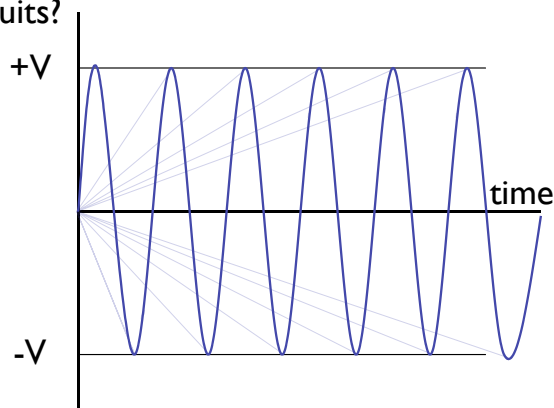
04-10-08  
Electrical Safety

## Announcements



- Haley Joel Osment (20)
- Quiz Announcements.
- Office Hours Monday morning 8-10.
- Test Next Week in lab covering Chapters 8-12

How do you talk about AC circuits as opposed to DC circuits?



$$V_{\text{rms}} = V/\sqrt{2}$$

In wall:

$$V_{\text{rms}} = 120\text{V}$$
$$V_{\text{max}} = 170\text{V}$$

To make this look like a DC circuit for purposes of calculation, use averaged values.  
A root-mean-square value is used to describe AC circuits.

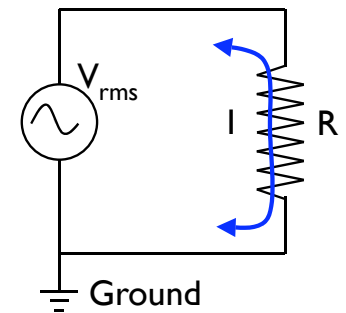
What do the circuits look like?

The voltage actually oscillates between  $+V_{\text{max}}$  and  $-V_{\text{max}}$ .  
What does this do to the current in the circuit?  
The current oscillates between  $+I_{\text{max}}$  and  $-I_{\text{max}}$ .

We'll denote the current in an AC circuit by the RMS value:

$$I_{\text{rms}} = I_{\text{max}}/\sqrt{2}$$

We can treat AC circuits just like DC circuits by using the RMS values of Voltage and Current.



### Effects of electrical shock as a function of current.

For an average male shocked through intact skin for one second by 60 Hz ac. Values for females are 60% - 80% of those listed.

Current (mA)	Effect
1	Threshold of sensation.
5	Maximum harmless current
10-20	Onset of sustained muscular contraction; can't let go for duration of shock.
50	Onset of pain; heart still unaffected.
100-300+	Ventricular fibrillation possible; very often fatal.
300	Onset of burns (thermal hazard); depends on concentration of current.
6000 (6A)	Onset of sustained ventricular contraction and respiratory paralysis; both cease when shock is over; heartbeat often returns to normal.

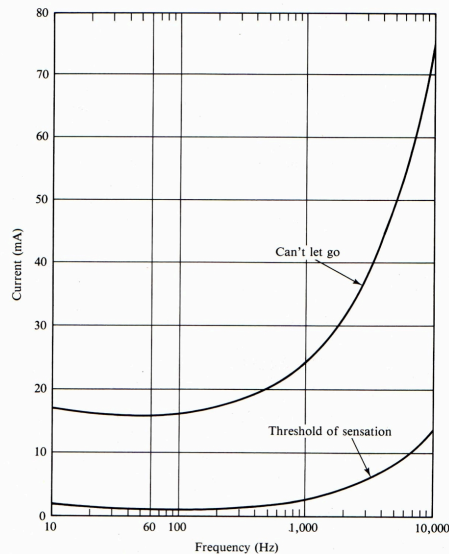
### Effects of electrical shock as a function of current.

For an average male shocked through intact skin for one second by 60 Hz ac. Values for females are 60% - 80% of those listed.

Currents as small as 20  $\mu\text{A}$  can cause ventricular fibrillation in micro-shock sensitive patients. These currents are too small to feel but fatal to some patients. An example of a micro-shock sensitive patient is anyone with "exposed" pacemaker leads. These leads lead straight to the heart and can focus a small current on the heart.

In contrast, a defibrillator can pass 6 A through the chest to reset the heart. This current is not focused but spread throughout the chest area.

12.1 PHYSIOLOGICAL EFFECTS OF ELECTRICAL SHOCK

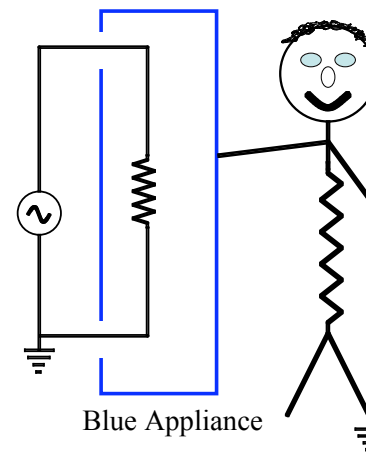


Shock effects depend on the frequency of the ac source.

Note the lowest voltage needed to cause problems is around 60 Hz. (This is the frequency used in the US for transmission.)

"Physics with Health Science Applications," P. Urone

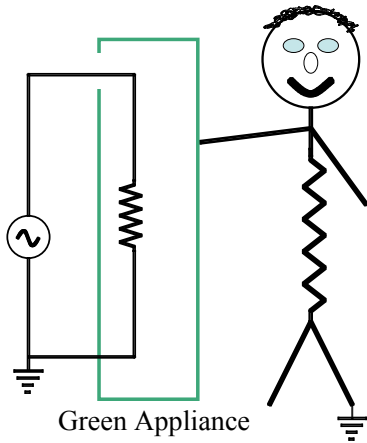
When is there a problem?



The appliance case is not connected to the circuit. The voltage on the case is zero.

Don't Worry, Be Happy

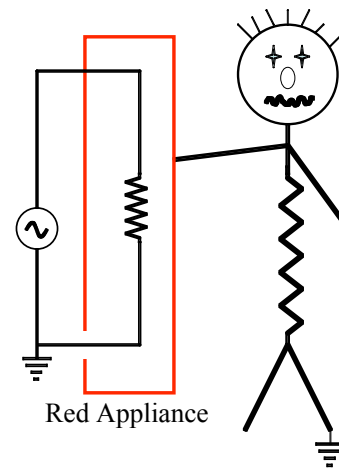
When is there a problem?



The appliance case is shorted on the grounded end of the circuit. The voltage on the case is still zero.

Still: Don't Worry, Be Happy

When is there a problem?

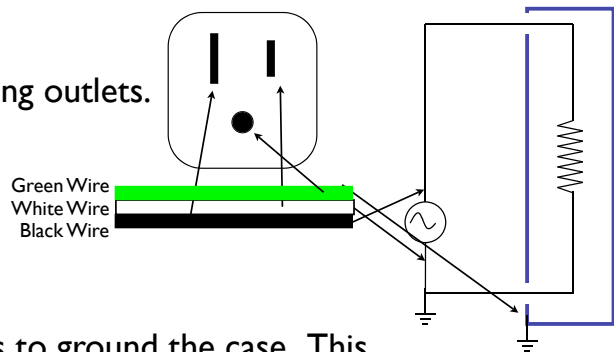


The appliance case is shorted on the high voltage end of the circuit. The voltage on the case is now 120V.

Worry, Don't Be Happy

What are the basics of Electrical Safety?

Three prong outlets.

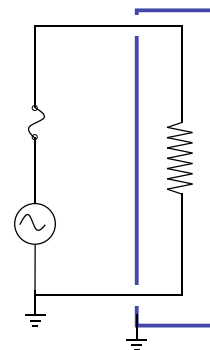


The idea is to ground the case. This keeps the case at 0V and prevents electric shock to anyone touching it.

What other problems can this lead to?

Heat, if the case provides a small resistance, a relatively large current can run through the case to ground. This may produce a lot of heat raising the possibility of fire or burns.

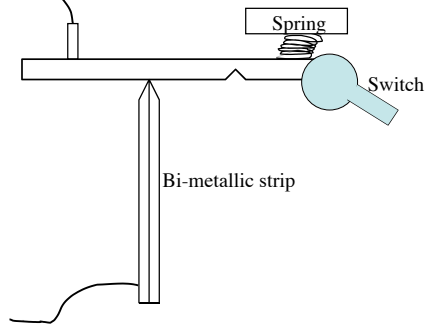
How do you handle this?



Fuses are used to put an upper limit on the amount of current that can flow in a circuit. When too much current flows in the circuit, the metal in the fuse heats up and melts disconnecting the circuit.

Another current limiting device is the circuit breaker seen on most power strips and in your circuit box at home.

How does this work? One possible setup is to use bimetallic strips with different heat expansion coefficients.

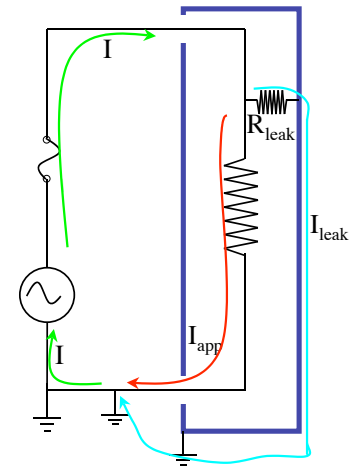


Detecting small variations.

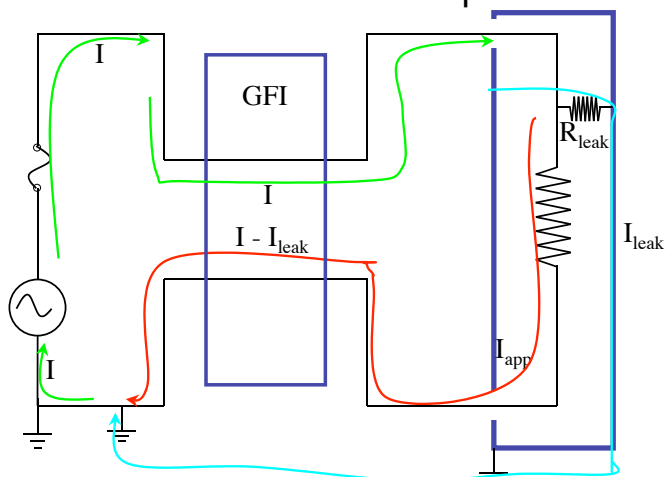
Leakage Current:  
This is the current that leaks out through a short in the circuit.

$$I = I_{app} + I_{leak}$$

How do you protect against this?



Ground Fault Interrupter



If  $I \neq I_{leak}$  and the difference is large enough, the GFI will disconnect the appliance.

A different kind of connection.  
Insolation Transformer

