Electric Hazards

Thermal Hazards
- __________ energy converted to __________ energy __________ than can be __________
- Happens in __________ circuits where electricity __________ between two parts of __________ bypassing the __________ load
  - $P = \frac{V^2}{R}$
  - Low __________ so high __________
  - Can start __________
  - __________ __________ or __________ try to stop
- Or __________ wires that have
  - __________ resistance (__________)
  - Or are __________ so __________ can’t __________

Shock Hazards
- Factors
  - __________ of __________
  - __________ of current
  - __________ of shock
  - __________ of current
- Human body mainly __________, so decent __________
- __________ are controlled by __________ impulses in nerves
  - A shock can cause __________ to __________
  - Cause __________ to close around __________ (muscles to close, stronger than to open)
  - Can cause __________ to __________
- Body most sensitive to __________ Hz

Table 20.3 Effects of Electrical Shock as a Function of Current

<table>
<thead>
<tr>
<th>Current (mA)</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Threshold of sensation</td>
</tr>
<tr>
<td>5</td>
<td>Maximum harmless current</td>
</tr>
<tr>
<td>10–20</td>
<td>Onset of sustained muscular contraction; cannot let go for duration of shock; contraction of chest muscles may stop breathing during shock</td>
</tr>
<tr>
<td>50</td>
<td>Onset of pain</td>
</tr>
<tr>
<td>100–300+</td>
<td>Ventricular fibrillation possible; often fatal</td>
</tr>
<tr>
<td>300</td>
<td>Onset of burns depending on concentration of current</td>
</tr>
<tr>
<td>6000 (6 A)</td>
<td>Onset of sustained ventricular contraction and respiratory paralysis; both cease when shock ends; heartbeat may return to normal; used to defibrillate the heart</td>
</tr>
</tbody>
</table>

Homework
1. What are the two major hazards of electricity?
2. Why isn’t a short circuit a shock hazard?
3. What determines the severity of a shock? Can you say that a certain voltage is hazardous without further information?
4. Some devices often used in bathrooms, such as hairdryers, often have safety messages saying “Do not use when the bathtub or basin is full of water.” Why is this so?
5. We are often advised to not flick electric switches with wet hands, dry your hand first. We are also advised to never throw water on an electric fire. Why is this so?
6. Before working on a power transmission line, linemen will touch the line with the back of the hand as a final check that the voltage is zero. Why the back of the hand?
7. (a) How much power is dissipated in a short circuit of 240-V AC through a resistance of 0.250 Ω? (b) What current flows? (OpenStax 20.85) 230 kW, 960 A
8. What voltage is involved in a 1.44-kW short circuit through a 0.100-Ω resistance? (OpenStax 20.86) **12 V**

9. Find the current through a person and identify the likely effect on her if she touches a 120-V AC source: (a) if she is standing on a rubber mat and offers a total resistance of 300 kΩ; (b) if she is standing barefoot on wet grass and has a resistance of only 4000 Ω. (OpenStax 20.87) **0.400 mA** (no effect), **26.7 mA** (muscular contraction)

10. While taking a bath, a person touches the metal case of a radio. The path through the person to the drainpipe and ground has a resistance of 4000 Ω. What is the smallest voltage on the case of the radio that could cause ventricular fibrillation? (OpenStax 20.88) **400 V**

11. Foolishly trying to fish a burning piece of bread from a toaster with a metal butter knife, a man comes into contact with 120-V AC. He does not even feel it since, luckily, he is wearing rubber-soled shoes. What is the minimum resistance of the path the current follows through the person? (OpenStax 20.89) **1.20 × 10^5 Ω**

12. (a) During surgery, a current as small as 20.0 μA applied directly to the heart may cause ventricular fibrillation. If the resistance of the exposed heart is 300 Ω, what is the smallest voltage that poses this danger? (b) Does your answer imply that special electrical safety precautions are needed? (OpenStax 20.90) **6.00 mV**

13. (a) What is the resistance of a 220-V AC short circuit that generates a peak power of 96.8 kW? (b) What would the average power be if the voltage was 120 V AC? (OpenStax 20.91) **1.00 Ω, 14.4 kW**

14. A heart defibrillator passes 10.0 A through a patient’s torso for 5.00 ms in an attempt to restore normal beating. (a) How much charge passed? (b) What voltage was applied if 500 J of energy was dissipated? (c) What was the path’s resistance? (d) Find the temperature increase caused in the 8.00 kg of affected tissue. (OpenStax 20.92) **5.00 × 10^{-2} C, 10.0 kV, 1.00 kΩ, 1.79 × 10^{-2} °C**