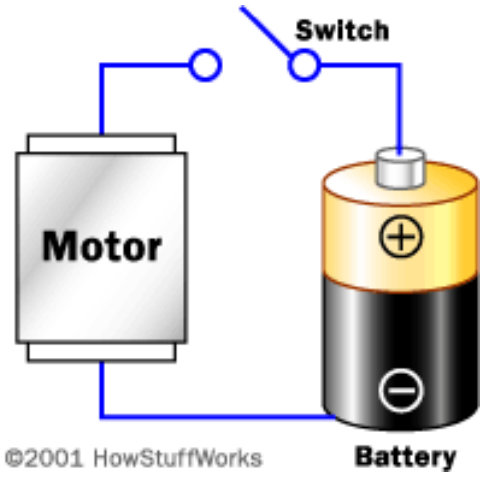
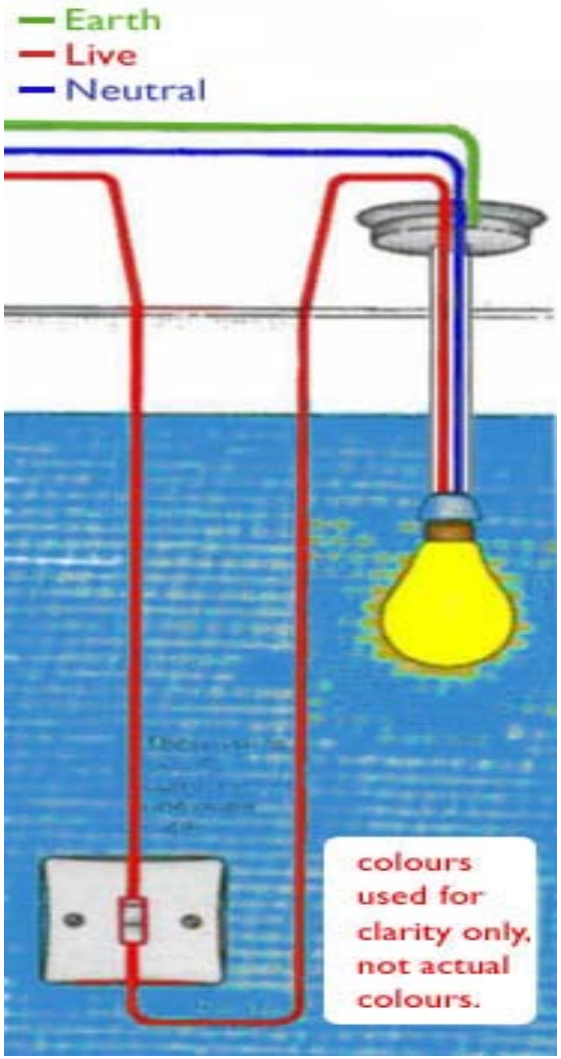
Basic
Electrical Safety

January 2009

The complete circuit

A complete **Circuit** or **loop** is necessary for current to **flow**





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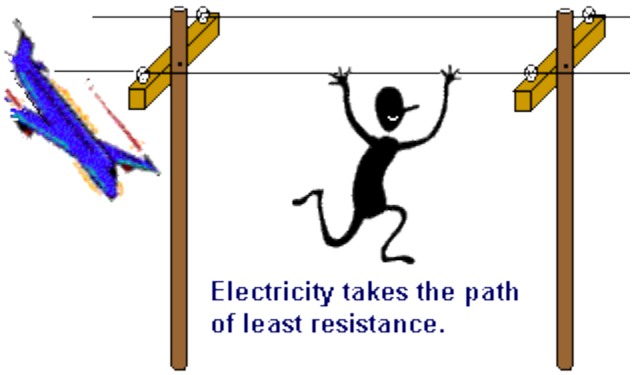
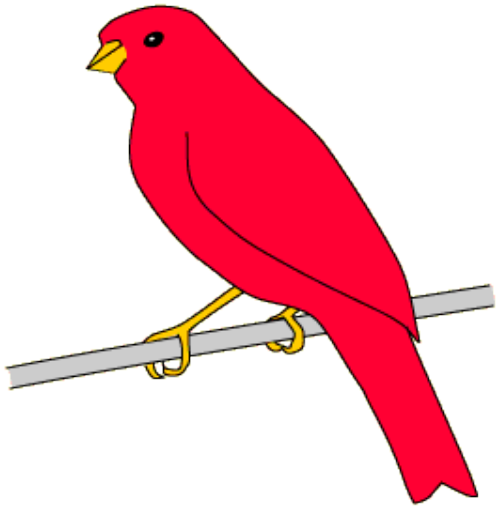
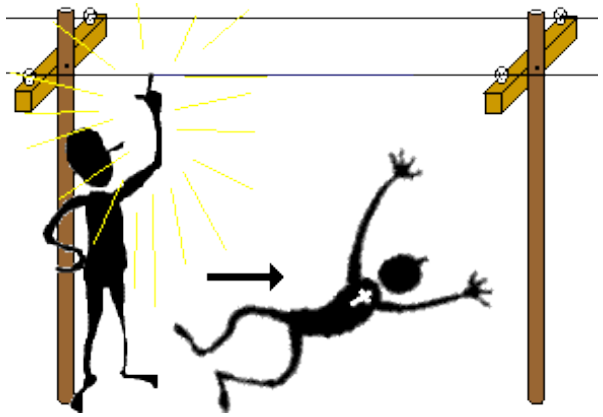


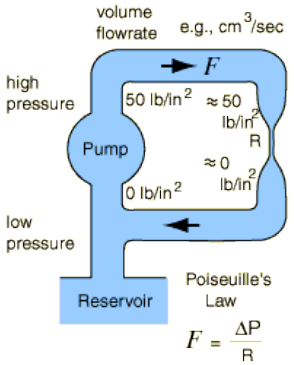
Current takes the path of least resistance

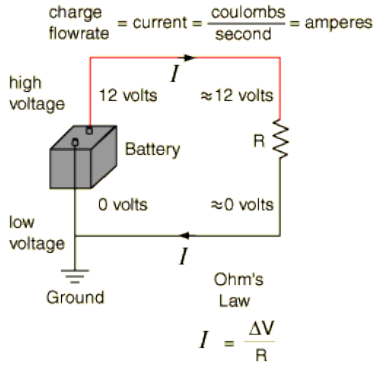




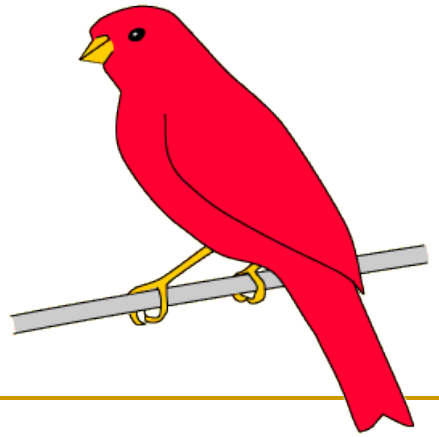
Basic Electrical Theory

- **Voltage** causes a **Current** to flow
  - Water analogy





- A complete **Circuit** is necessary for current **to flow**
  - Bird on HT wires



Voltages

- Low Tension 0 => 50V
  - Batteries: AA, AAA, MP3 player
  - Car, trucks, busses **12** / 24 / 48
  - Garden lights, domestic halogen lights
- High Tension 100 => 300V
  - EU Mains, Electrophoresis, DART, Capacitors SM PSUs
- Very High Tension 1KV +
  - ESB pylons, TV tubes, photocopiers, X-Ray machines, Mass Spectrometers

Electricity in the body

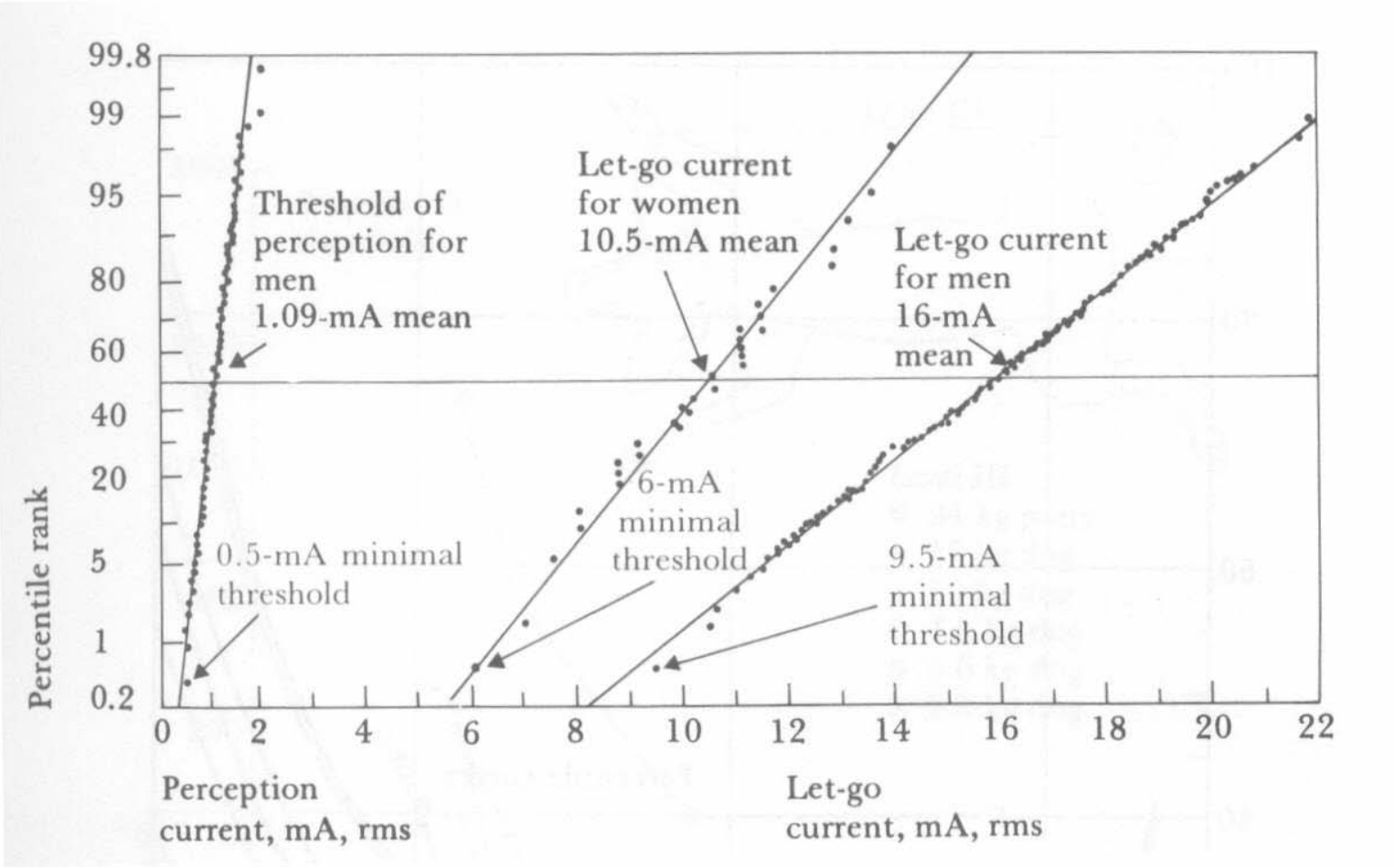
Electricity in the body

- ***Muscles***
  - Muscles control all the body movements
  - Including & importantly those that keep us alive - **Breathing** and **Heart**
  - The brain controls voluntary muscles using **Current pulses** along nerves

Electricity in the body

- ***External current*** *through the body causes*
  - Loss of muscle control
  - Spasms & Involuntary movement
  - Inability to let go
  - Burns - external & internal

Perception thresholds and let-go currents for men and women



Electricity
&
associated hazards

Electricity - associated Hazards

- Indirect Injury
  - Falls from ladder
  - Thrown back. Fall to ground, onto sharp edge
  - Drop objects
  - Thermal burns – Very hot equipment surface, explosion
- Wires & cables - Trailing leads => trips & damage,
  Re-route, tidy up, cover over
- Life Support muscles
  - Diaphragm and breathing
  - Heart Fibrillation Random, uncoordinated heart contractions
  - De-fribrillation: High voltages (3000 V at 20 A) fraction of a second
- Burns - death of tissue
  - Internal [organs]
  - External [skin]

END

[I] Electrical Theory Section

Electrical Appliances

Safety guiding principle

*"keep currents and voltages **inside** apparatus and **away** from our bodies"*

- Inherently safe - Low voltage / low current
- Enclosures
- Insulation
- Safe & secure connections

Electrical cables & plugs

Mains cable

- **Brown** Live - power
- **Blue** Neutral
- **Green/yellow** Earth

Electrical cables & plugs

Mains cable

- **Brown** Live power
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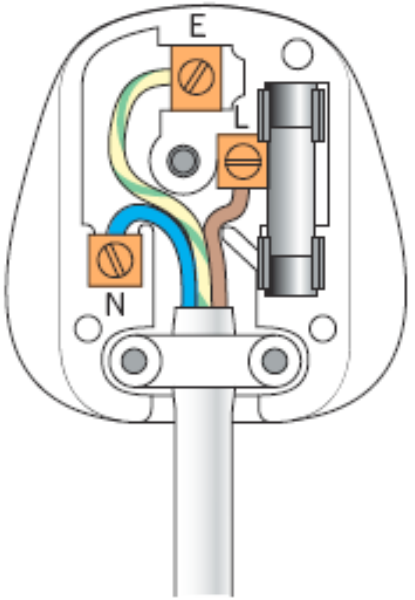
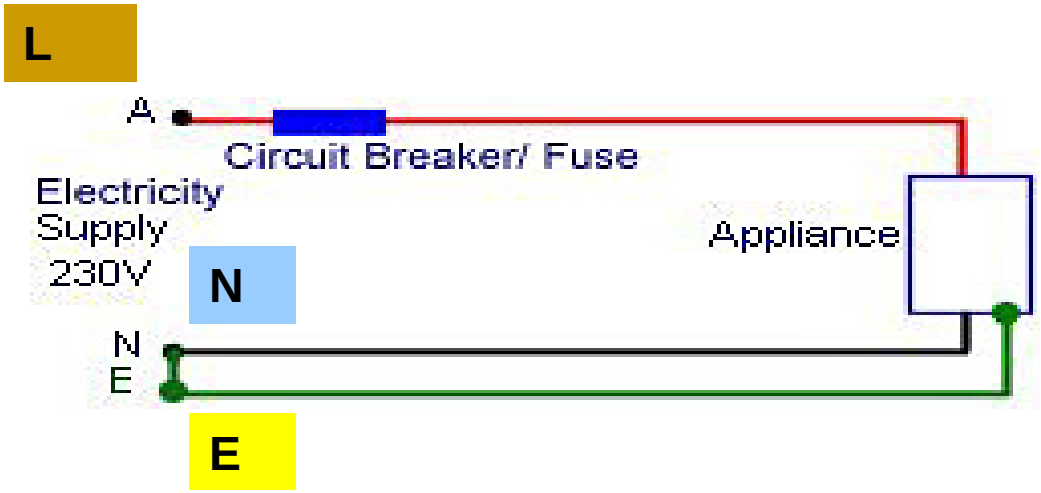


Live, Neutral, Earth & Fuses



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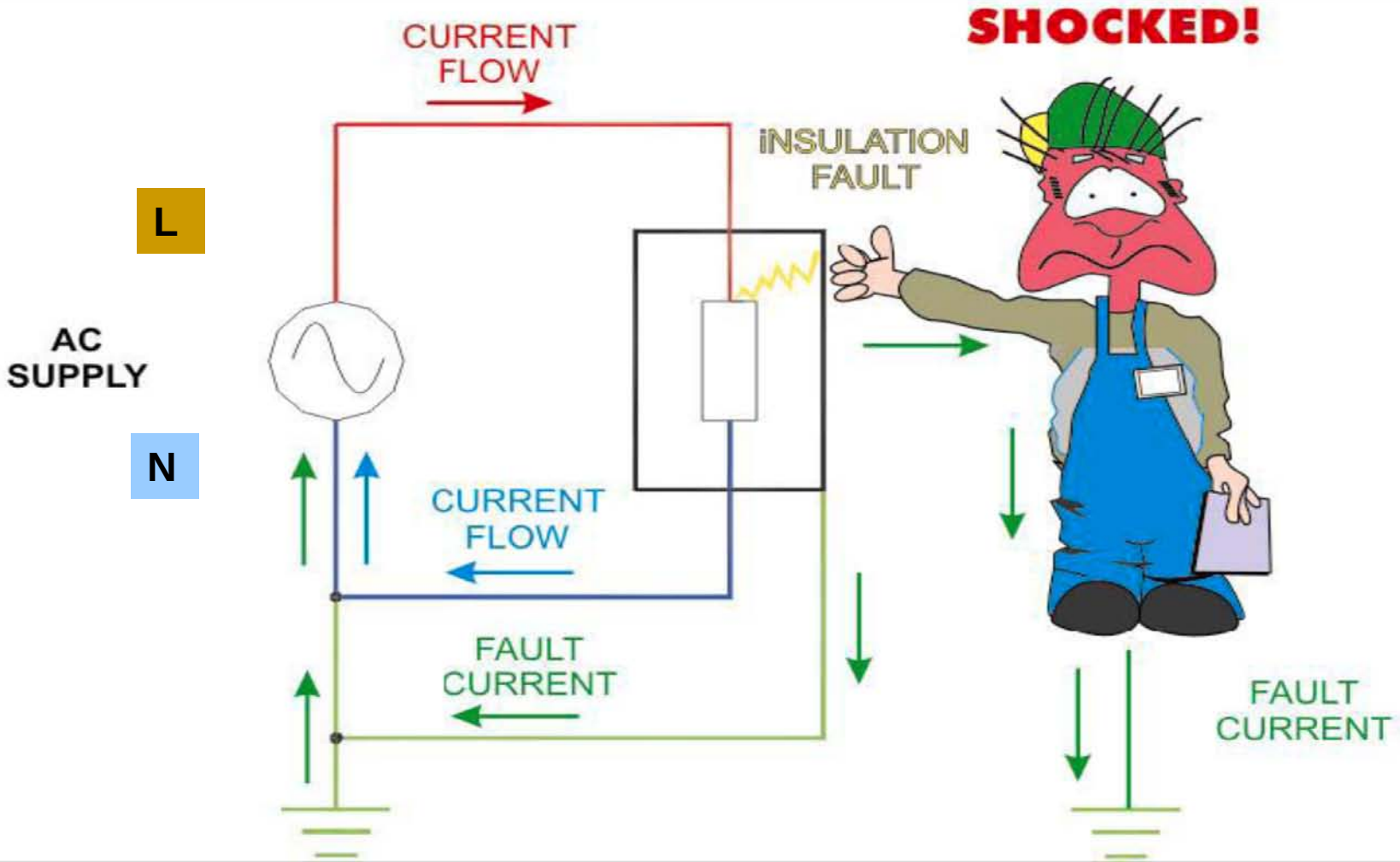
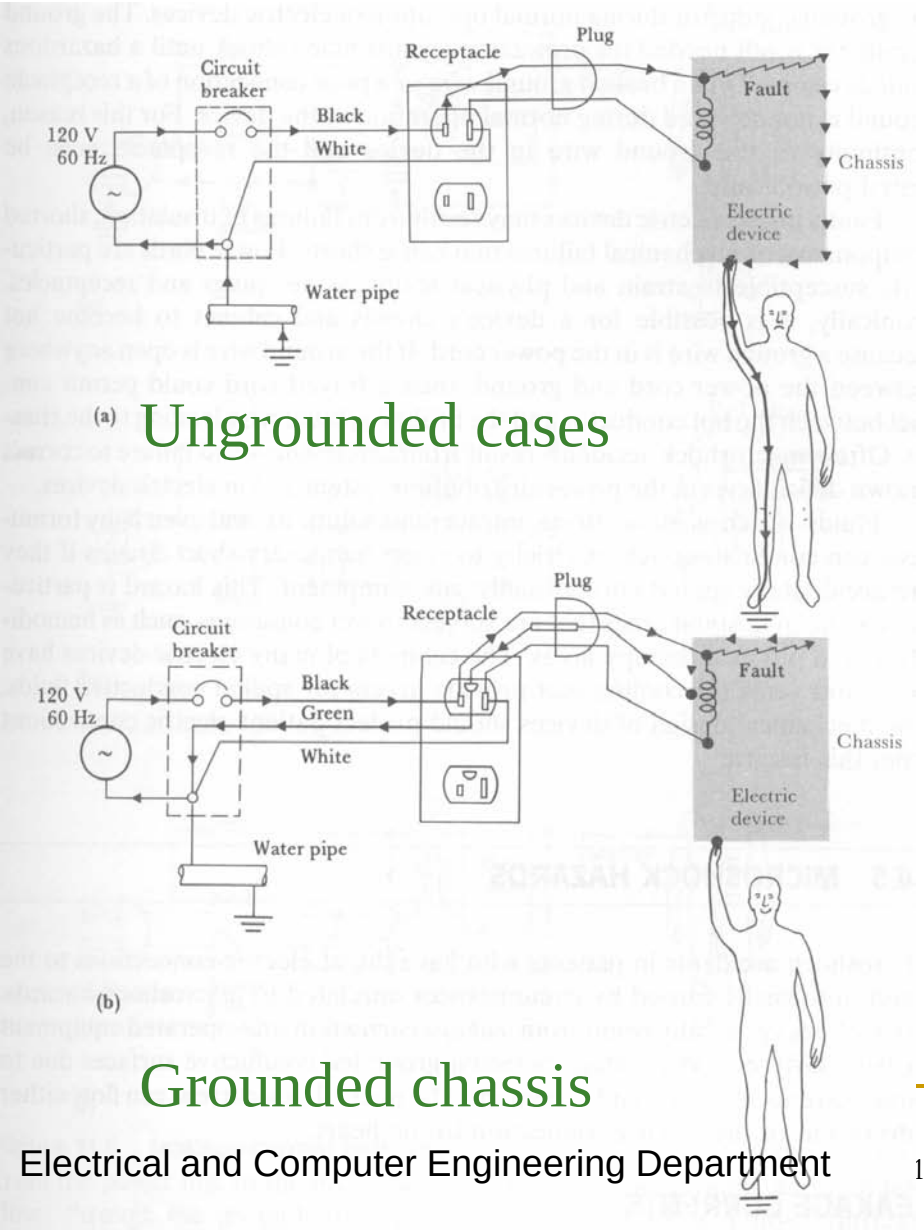
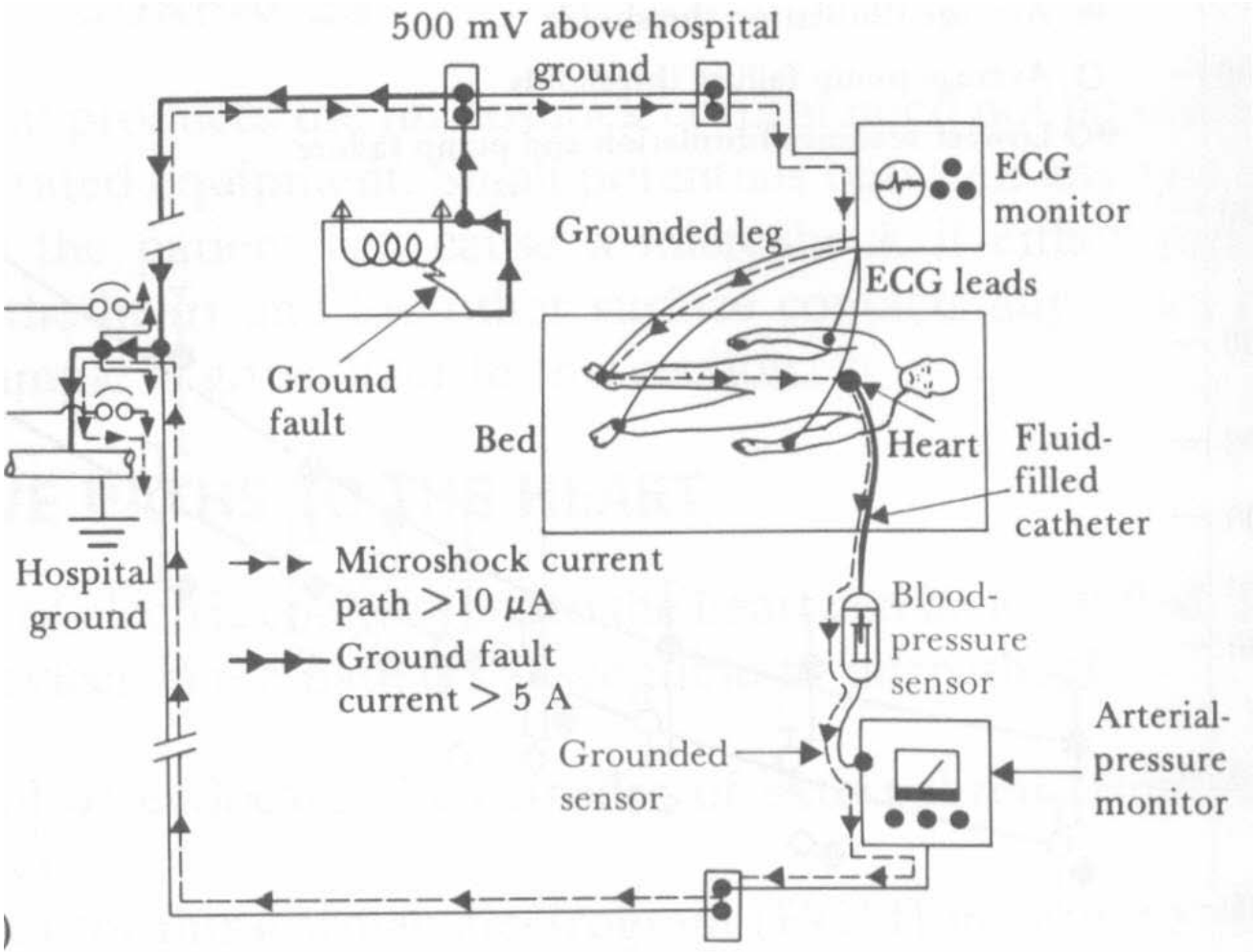


Shocks due to ground fault from hot line to equipment cases



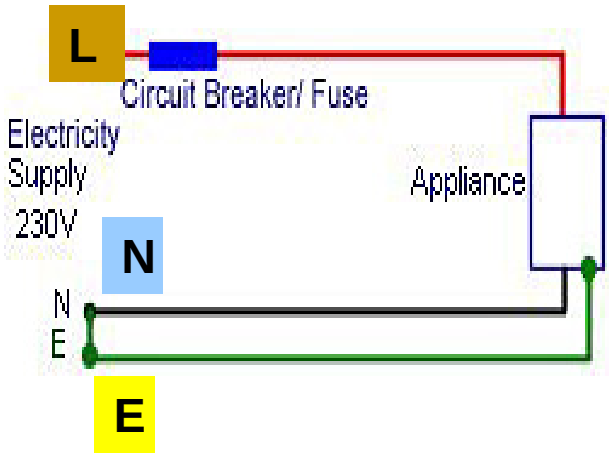
- The ground conductor is not needed for operation of the equipment.
- It is not needed either for protection against shock until a hazardous fault develops.
- Hence, a broken ground wire or a poor connection is not detected during normal operation.
- Ground wire provides lower resistive path to ground than patient
- Continuity of the ground wire and the receptacle must be tested periodically

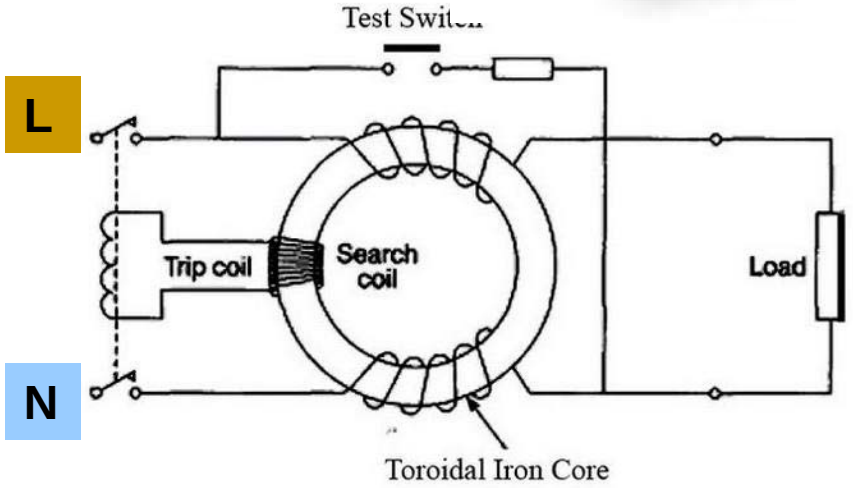
Microshock via ground potential differences



RCD **Residual Current Device**
RCCB **Residual Current Circuit Breaker**
ELCB **Electric Leakage Circuit Breaker**
MCB **Magnetic Circuit Breakers**
RCBO **Residual Current Breaker with Overcurrent protection**

- current difference of >30 mA
- for a duration of >30 ms





Live, Neutral, Earth & Fuses

- The **Live** and **Neutral** wires carry current around the circuit
- The **Earth** wire is there to protect you.
  - The Earth wire can act like a back-up **Neutral** wire,
  - Many appliances have metal cases e.g. kettles, toasters, dishwashers, washing machines etc. Therefore, the case needs to be grounded
- The **Fuse** is very thin piece of wire.
  - The wire has a quite low melting point. As current flows through the wire it heats up.
  - If **too large a current** flows it **melts**, thus **breaking** the circuit
  - Use appropriate fuse size/rating
- Additional safety devices - RCDs, ELCBs, MCBs

Guidelines

- Use low & safe voltages
  - EU 230 VAC / US 110 VAC Hz
- Select equipment appropriate for environment & use
- Use equipment as per manufacturer's instruction & design
- Ensure adequate preventive maintenance
- Insulate and enclose live parts
- Prevent conducting parts from becoming live. Earth, double insulation separate supply from earth, limit electric power
- Avoid electricity where its use could be dangerous. Rubbing, Induction & Capacitance effects can build up static electricity
- Toxic - Berilium heat sinking, Incomplete burning can produce carbon monoxide

END

[II] Electrical Appliances

Electrocution

- Prevention & Training : Where are red mushroom switches ?
- Response: Immediately cut power, red buttons / switch / plug
- If in any doubt - Do not touch victim.
- One hand behind back, stand on insulation, tip with back of hand
- Use insulating rod / stick to move wires from victim.
- Call for assistance
- Talk & reassure victim
- If unconscious then use first aid, CPR

Electrical Hazards & Personal Safety

- Where
  - Office & home 95%
  - Laboratory 5%
    - Trailing wires, faulty wires
- Mains
  - Avoid direct working with mains. Use only low voltages (tension)
  - Check all leads for: Fraying, Proper clamping, Proper grounding.
- Repairing
  - Do not repair, competency required
  - One hand behind back, tip cautiously with back of hand
  - Trust nobody, remove fuse, use phase tester
  - When opening the covers of a device, TURN OFF POWER
  - **Note**: Switch Mode PSU, laptop chargers, CF lamps
    [high voltages persists on capacitors long after switch off]

Specific Hazards & Personal Safety

- Medical / sports equipment
  - Very strict regulations on equipment operation, design, repair
  - Never modify or tamper with such equipment
  - ECG measurements. even a few micro amps in a susceptible location can have massive consequences [Basis of Heart pacemaker]
- Pace makers
  - Susceptible to strong magnetic fields [NMR!],
  - Possibly RF & Micro waves
- Solvent
  - Flammable environments require specialised electrical equipment E.g. Fridge storage of samples stored in solvents
- Cold rooms / water cooling
  - Equipment moved from a cold room with get condensation on its internal electrical
  - circuits Avoid this movement, Use LT, give lots of time to acclimatise

Specific Hazards & Personal Safety

- RF & µW
  - Capacitive coupling, no need to touch,
  - Both can burn severely internally and externally depending on how focused. Think of them like an open air µ-wave oven
- HT & Sparks
  - Static, OK [Very low current, moderate power]
  - Will jump considerable distances, beware of capacitors
- Power
  - Heating effect in body => internal burns / damage
  - Contact burns, deep burns & necrosis
- Trailing power and signal wires - Protect & Tidy them up

Specific Hazards & Personal Safety

- Other Laboratory Situations
- Other Office Situations
- Other Home Situations

Where to get more Information

- Your Supervisor, Manager, Head of Department
- Department Safety Statements
- Department Safety Committees & Safety Officer
- DCU safety - WEB
- Edinburgh H&S - WEB
- University London H&S - WEB

Summary

- Awareness of the need for electrical safety
- Introduction to the source of electrical dangers
- Your responsibility to take care of yourself and others

END

What's the problem?