1. Hazards of Electricity

- frayed cables
- long cables
- damaged plugs
- water around sockets
- do not put metal objects into sockets

Why should you not change a plug with wet hands? (water conducts electricity so you could get an electric shock)

2. Insulation and Double Insulation

- Wire insulation:
  - Grips outer cable and prevents strain on the inner coloured wires
  - Is an insulator, stops current flowing from wire
- Double Insulation:
  - Plastic exterior means that even if live wire touches case user will not receive a shock
  - Symbol: 

Why does a double insulated device not require an earth wire? (the outside is not metal so it cannot conduct electricity and give you a shock)
- Draw the symbol for double insulation (above)

3. Earth, Fuses and Circuit Breakers

- Earth:
  - The Earth wire connects the outside of the case to the Earth
  - Protects from electric shock with metal cased appliances
  - If the outside case becomes connected to the live wire a large current will be dissipated to earth
  - The large current will melt the fuse
- Fuse:
  - O Melt when too much current flows
  - Value of fuse must be higher than current drawn by the device otherwise it would melt immediately
  - Must be connected to live wire
- Circuit Breaker (same as fuse but can be reset manually)
  - Breaks the circuit when too much current flows
  - Must be connected to live wire

- What size fuse 1.2.5.6.9A fuse should you use in a 5A device (6A)?
- When does a fuse melt? (when the current is too large)
- What two things are connected to the earth wire? (the outside of the device and the Earth)

4. Electrical Heating

- As the electrons flow through a wire they will occasionally collide with an atom causing it to vibrate (KE)
- This results in a transfer of energy to the wire causing it to heat
- Examples of such equipment are: kettle, electric fire, electric oven, heat bulb, hair dryer, electrical radiators

- Equation:
  - Energy = voltage x current x time
  - \[ E = V I t \]

- A kettle has a voltage of 220V, and a current of 20A; if it uses 57200 joules, how long was the kettle turned on for? (13 minutes)
- A 12V immersion heater draws 2A of current for 100 seconds how much energy is transferred? (2400J)

5. Power

- Power is the "rate of doing work"
- Symbol: \( P \)
- Equation:
  - \[ P = V I \]
- Units:
  - watts (W)
  - 1W = 1J/S
  - i.e. a 100W light bulb transfers 100J of energy every second

- If the power of a light bulb is 60W, the mains voltage is 230V, what is the current? (0.26A)
- What fuse should be used for the answer above: 1A, 2A, 5A, 9A or 13A? (1A)

6. AC and DC

- **Alternating Current (A.C.)**
  - The current flows first one way then the other (it changes from positive to negative)
  - Mains: \( f = 50 \text{ Hz}, V = 240 \text{ V} \)
  - AC voltage can be changed using a transformer
- **Direct Current (D.C.)**
  - The current flows in one direction only and has a consistent value
  - Provided by batteries or DC adaptors plugged into the mains

- What is the difference between AC and DC? (Above)
- Name 3 things that use AC current and what uses DC current? (Above)
### 7. Voltage
- Measure of how much energy the electrons are carrying around to the things in the circuit
- Measured using a voltmeter in parallel
- Symbol: V
- Units: volts (V)
- **Voltage is the energy transferred per unit charge (SS only)**
- **Voltage is a joule per coulomb (SS only)**
- **Equation:**
  - $V = E / Q$ (SS only)
  - Thus $V = I / Q$ (SS only)
- If the resistance is lowered, and the voltage stays the same, what happens to the current? (increases)

### 8. Current
- Rate of flow of charge
- Thus faster or more electrons = bigger current
- Conventional current goes from positive to negative
- Normally, the charged particles are electrons
- Electrons are negative; they are attracted by a positive charge and therefore flow from negative to positive
- Measured using an ammeter in series
- Symbol: I
- Units: A (Ampere)
- An extra motor is added to the circuit, and the current must stay the same, what must you change? (increase V)
- What is the difference between conventional current and electron flow (conventional current goes from + to -; electrons go from - to +)

### 9. Resistance
- How hard it is for current to flow through a material.
- Symbol: R
- Units: Ω (ohms)
- **Note:**
  - This is due to the number of free electrons in a material and how hard it is for them to flow through the structure.
  - The hotter a wire, the more resistance as the ions are vibrating faster and so it is harder for the electrons to flow.
- What happens if you increase the resistance on a circuit and the voltage stays the same? (Current goes down)

### 10. Ohm's Law
- The resistance of a metal conductor is the same whatever the current, unless it gets hotter.
- **Equation:**
  - $V = IR$
  - **Voltage** = **Current** $\times$ **Resistance**
- If there is a current of 20A running through a circuit, and it has a resistance of 5 Ohms, what is the voltage? (100V)

### 11. Series Circuits
- All components are in a continuous loop.
- Any break in the circuit stops the current.
- Voltage of the power supply is shared across the components ($V = V_1 + V_2 + V_3$).
- Current does not change through the circuit (I is the same everywhere).
- Resistors in series, total the values:
  - $R_{total} = R_1 + R_2 + R_3$
- If the voltage at $V_1$ is 20 and $V_2$ is 15, and the total voltage is 55, what is the voltage at $V_3$? (20V)

### 12. Parallel Circuits
- Every branch has the same voltage.
- Current is shared out between the branches ($A_1 = A_2 = A_3 + A_4 = A_5$).
- The bigger the resistance on a branch, the smaller the share of the current (as $V = IR$, i.e. $A_4$ in the circuit shown).
- If the current at $A_5$ is 30, what is the current at $A_2$, $A_3$, and $A_4$? (10A)
<table>
<thead>
<tr>
<th>13. IV Graph: Wires and Resistors</th>
<th>14. IV Graph: Lamps and Bulbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Resistors obey ohms law: the voltage is directly proportional to the current.</td>
<td>- As the temperature increases the resistance increases.</td>
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<tr>
<td>- 1/gradient of the graph is resistance, so the steeper the graph the lower the resistance.</td>
<td>- The wire heats up.</td>
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<tr>
<td>- gradient = rise/run = I/V = 1/R (as V=IR)</td>
<td>- The ions in the filament vibrate more.</td>
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<tr>
<td>- If the gradient of the graphs is 50, what is the resistance? (0.02Ω)</td>
<td>- This makes it harder for the electrons to travel.</td>
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<td>- Thus its resistance has increased.</td>
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<td></td>
<td>- So for a large voltage increase there is only a small current increase when it is hot (the top and bottom of the graph).</td>
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<tr>
<td>15. IV Graph: Diodes</td>
<td>16. LDRs</td>
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<td>- A diode only lets current through one way.</td>
<td>- An LDR is a light dependent resistor. Its resistance decreases as the amount of light falling on it increases.</td>
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<td>- If there is a negative voltage no current flows.</td>
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<td>- It requires a small voltage to work (0.7V) so it only starts going up with +0.7V.</td>
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<tr>
<td>- What is the current on a diode when the voltage is negative? (No current)</td>
<td>- If the resistance of an LDR decreases, what happens to the amount of light it received? (Decreases)</td>
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<td>17. Thermistors</td>
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<td>- The resistance of a thermistor decreases as the temperature increases.</td>
<td>- Property of charged particles, the more particles the greater the charge.</td>
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<tr>
<td>- Note: this is because extra electrons are released making it easier for current to flow.</td>
<td>- Symbol: Q</td>
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<tr>
<td></td>
<td>- Equation: Q = It</td>
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<td></td>
<td>- Units: coulomb C</td>
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<td></td>
<td>- Charge on 1 electron = 1.6 x 10⁻¹⁹ C</td>
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<td></td>
<td>18. Charge</td>
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<tr>
<td>- If the temperature increases, what happens to the resistance of a thermistor? (decreases)</td>
<td>- What sort of charge does an electron have? (negative)</td>
</tr>
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<td>- What is current? (Rate of flow of charge).</td>
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</tbody>
</table>
19. Variable Resistors

- A variable resistor can have its resistance value changed.
- Often used in experiments to vary the current in a circuit or the voltage through another component.

- If you increase the resistance of the variable resistor and keep the voltage the same, what will happen to the current in the circuit? (go down)

20. Circuit Symbols (Part I)

- Thermistor
- Variable Resistor
- Light Dependent Resistor (LDR)
- Resistor

- Name a use of an LDR (street lights)
- Name a use of a thermistor (fridge)

21. Circuit Symbols (Part 2)

- Diode
- Fuse
- Motor
- Buzzer

- What is a diode used for? (to make sure that the electricity only flows one way)
- What is the function of a fuse in a circuit? (it melts and breaks the circuit if too much current flows through)

22. Static Charging (SS)

- Insulators can be charged by friction.
- If a material is turned positive, then electrons have been lost (e.g., the belt carries away electrons from the dome in a van de Graaff generator).
- If the material becomes negative, electrons have been gained.
- Like charges repel.
- Different charges attract.

- How do you charge a material (by friction)?
- If something has a positive charge, what has happened? (Some electrons have been removed)

23. Uses of Static Electricity (SS)

- Spray paint:
  - The paint is given a positive charge.
  - The droplets repel, making a fine mist.
  - The surface has a negative charge attracting the paint.

- Photocopiers:
  - An image of a page is projected onto a piece of paper.
  - The dark parts of the image make the paper positive.
  - Toner (ink) is negatively charged, so it is attracted to the positive parts of the paper.
  - It is then heated to fix it.

- Inkjet printers:
  - The spray of ink is positively charged.
  - It is attracted up or down by charged plates to change its direction.

- Would positively charged paint get attracted to a negatively charged surface? (yes)
- Why do you get a fine mist of paint (all the paint has a positive charge so they droplets repel each other)

24. Dangers of Static Electricity (SS)

- Static electricity can be built up by friction.
- When the voltage is high enough a tiny spark will be released.
- If this spark is nearby flammable or explosive materials, then this could ignite them, and cause an explosion.
  - E.g., refueling an airplane, friction of the gasoline against an insulator (plastic) entering the plane builds a charge.

- How is static electricity built up? (friction)
- If a material has a positive charge what must have happened? (electrons have been removed)