ELEARNSA

DEPARTMENT OF TECHNOLOGY & NATURAL SCIENCES

GRADE 9 TECHNOLOGY

TERM 3 ASSESSMENT ANALYSIS & STUDY GUIDE

COMPREHENSIVE CAPS CURRICULUM PREPARATION

STUDY GUIDE INCLUDES:

- Complete Test Topics Analysis & Breakdown (50 Marks)
- Core Theory: Circuits, Components & Electromagnetism
- Step-by-step Mathematical Working & Ohm's Law
- Microcontrollers (Arduino & micro:bit) & Tinkercad
- Full Practice Examination with Solutions
- Printable Quick Reference Formula & Symbol Cards

Academic Year: 2026
Subject Lead: Technology Faculty
Date: September 2026
Format: Comprehensive Guide

SECTION 1: INTRODUCTION & ASSESSMENT OVERVIEW

Welcome Grade 9 Learners!

This study guide has been specifically developed to prepare you for your **Term 3 Technology Assessment**. It covers all core theoretical principles, calculations, component functions, microcontrollers, and design applications required by the CAPS curriculum.

Table of Contents

Term 3 Assessment Breakdown (Total: 50 Marks)

Section	Topic / Focus Area	Marks	Cognitive Level / Skills
Section A	Multiple Choice Questions	10 Marks	Recall, Basic Calculations, Concepts
Section B	Matching Columns	5 Marks	Terminology & Component Functions
Section C	Definitions & Key Concepts	10 Marks	Understanding & Technical Explanation
Section D	Circuit Diagrams & Analysis	10 Marks	Drawing Symbols, Parallel Resistance Logic
Section E	Mathematical Calculations	10 Marks	Ohm's Law, Power, Energy & Efficiency
Section F	Design Application Challenge	5 Marks	Problem Solving, Irrigation System, Microcontroller Pins

💡 **Proven Study Tips for Technology:**

1. **Practice Drawing:** Never just look at circuit symbols — practice drawing them neatly using a ruler.
2. **Master the Formula Triangles:** Learn how to cover the unknown variable to rearrange equations effortlessly ($V = I \times R$ and $P = V \times I$).
3. **Units Matter:** Always write units in your final answer (e.g., Ω, V, A, W, J, $\%$) to avoid losing unnecessary marks!

SECTION 2: ELECTRICAL CIRCUITS & SYMBOLS

1. Series vs. Parallel Circuits

Series Circuits

In a series circuit, components are connected **end-to-end** in a single continuous loop.

- **Current (I):** Same at every point in the circuit.
- **Voltage (V):** Shared/divided across components.
- **Total Resistance (R_T):** Increases as more resistors are added.

$$R_T = R_1 + R_2 + R_3 + \ldots$$

Parallel Circuits

In a parallel circuit, components are connected in **separate branches** across the same points.

- **Voltage (V):** Same across all branches.
- **Current (I):** Divided among the parallel branches.
- **Total Resistance (R_T):** Decreases with extra branches.

$$R_T = (R_1 \times R_2) \div (R_1 + R_2)$$

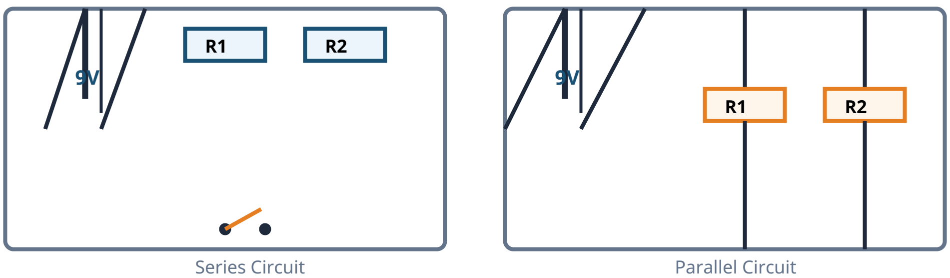
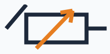


Figure 2.1: Schematic Comparison of Series and Parallel Configurations

💡 **Key Concept: Why is Parallel Resistance Smaller than the Smallest Resistor?**

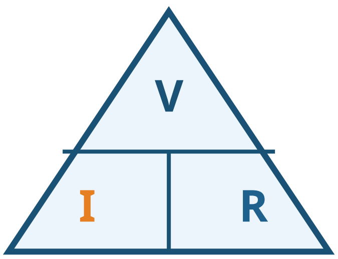
Adding parallel branches provides *multiple pathways* for electrons to flow. Think of it like opening additional lanes on a busy highway — even if a new lane is narrow (high resistance), it still allows more total traffic (current) to flow, reducing overall congestion (total resistance).

2. Standard Circuit Symbols Reference Sheet

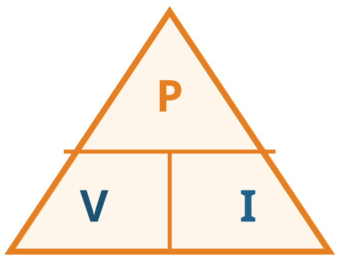
Component	Symbol Diagram	Function & Key Notes
Cell / Battery		Provides chemical energy converted into electrical energy (DC). Longer line = Positive terminal (+).
Resistor (Fixed)		Restricts or limits current flow in a circuit. Value measured in Ohms (Ω).
Potentiometer		Variable resistor with 3 terminals. Used as a voltage divider or volume/ speed control.
Switch (SPST)		Controls circuit continuity. Open switch = Broken circuit (OFF); Closed switch = Complete circuit (ON).
Ammeter		Measures electrical current (I) in Amperes (A). **Must be connected in SERIES.**
Voltmeter		Measures potential difference (V) in Volts (V). **Must be connected in PARALLEL.**
Light Emitting Diode (LED)		Semiconductor light source. Allows current to flow in ONE direction only (Polarized: Anode + / Cathode -).
Electric Motor		Converts electrical energy into mechanical rotational motion.

SECTION 3: OHM'S LAW & POWER CALCULATIONS

Ohm's Law states that the current flowing through a conductor between two points is directly proportional to the voltage across the two points, provided physical conditions (like temperature) remain constant.



Ohm's Law Triangle



Electrical Power Triangle

$V = I \times R$ (Voltage = Current × Resistance)

$I = V \div R$ (Current = Voltage ÷ Resistance)

$R = V \div I$ (Resistance = Voltage ÷ Current)

$P = V \times I$ (Power = Voltage × Current)

$P = I^2 \times R$ (Power = Current² × Resistance)

$P = V^2 \div R$ (Power = Voltage² ÷ Resistance)

Step-by-Step Worked Calculations Examples

Example 1: Calculating Parallel Resistance & Total Current

Problem: Two resistors, $R_1 = 6\ \Omega$ and $R_2 = 12\ \Omega$, are connected in parallel across a $12\ V$ power supply. Calculate (a) Total Resistance (R_T) and (b) Total Current (I_T).

Solution:

Step (a): Calculate Total Resistance (R_T)
Formula: $R_T = (R_1 \times R_2) \div (R_1 + R_2)$
Substitution: $R_T = (6 \times 12) \div (6 + 12) = 72 \div 18 = 4\ \Omega$

Step (b): Calculate Total Current (I_T)
Formula: $I = V \div R_T$
Substitution: $I = 12\ V \div 4\ \Omega = 3\ A$

Example 2: Power Dissipation Calculation

Problem: A resistor of $10\ \Omega$ has a current of $2\ A$ passing through it. Calculate the power dissipated as heat.

Solution:
Formula: $P = I^2 \times R$
Substitution: $P = (2)^2 \times 10 = 4 \times 10 = 40\ W$

SECTION 4: ELECTROMAGNETISM (MOTORS & GENERATORS)

1. Electromagnetic Induction

Electromagnetic induction is the production of an electromotive force (voltage) across an electrical conductor in a changing magnetic field. Discovered by Michael Faraday, it forms the foundation of modern power generation.

2. Electric Motors vs. Electric Generators

Electric Motor

Energy Conversion:
Electrical Energy → Mechanical Energy

Operating Principle:
A current-carrying conductor placed within a magnetic field experiences a mechanical force (Motor Effect).

Key Components:

- **Armature/Rotor:** Rotating coil of wire.
- **Commutator (Split-ring):** Reverses current every half-rotation to maintain unidirectional spinning.
- **Carbon Brushes:** Maintain sliding contact with the rotating commutator.
- **Permanent Magnets:** Provide uniform magnetic field (N to S).

Electric Generator (Dynamo)

Energy Conversion:
Mechanical Energy → Electrical Energy

Operating Principle:
Rotating a coil inside a magnetic field cuts magnetic flux lines, inducing an electrical current (Electromagnetic Induction).

Key Components:

- **Mechanical Prime Mover:** Turbine, hand crank, or engine turning the shaft.
- **Rotor / Stator:** Moving and stationary electromagnetic elements.
- **Slip Rings (AC) or Commutator (DC):** Collects induced current.

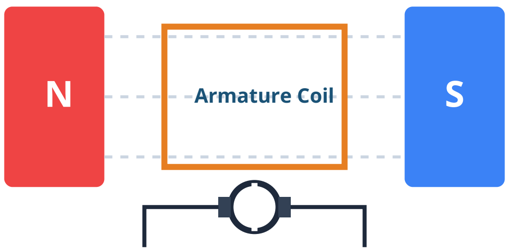


Figure 4.1: DC Electric Motor Cross-Section Showing Armature, Magnets, & Commutator

SECTION 5: EFFICIENCY & ENERGY CALCULATIONS

1. Energy Conversion & Efficiency

No electrical device is 100% efficient. Some input energy is always transformed into unintended form—most commonly **heat energy due to resistance** ($P = I^2R$) or sound friction.

$$\text{Efficiency (\%)} = (\text{Useful Energy Output} \div \text{Total Energy Input}) \times 100$$

2. Energy Calculation Formula

$$E = P \times t$$

Where E = Energy in Joules (J), P = Power in Watts (W), and t = Time in seconds (s).

3. Sankey Energy Flow Diagram

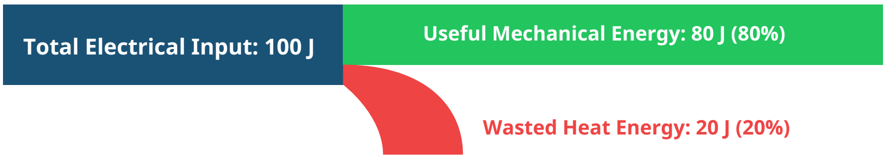


Figure 5.1: Energy Flow Diagram for an Electric Motor Operating at 80% Efficiency

Worked Calculation: Motor Efficiency

Problem: An electric motor draws *250 W* of electrical power from a supply. It produces *200 W* of useful mechanical power. Calculate:
(a) The motor efficiency percentage.
(b) The energy wasted in 2 minutes of continuous operation.

Solution (a):
$Efficiency = (Useful\ Output \div Total\ Input) \times 100$
$Efficiency = (200\ W \div 250\ W) \times 100 = 80\%$

Solution (b):
Wasted Power = $250\ W - 200\ W = 50\ W$
Time in seconds = $2\ minutes \times 60\ s = 120\ s$
$E_{wasted} = P_{wasted} \times t = 50\ W \times 120\ s = 6\ 000\ J\ (or\ 6\ kJ)$

SECTION 6: MICROCONTROLLERS & PROGRAMMING

1. What is a Microcontroller?

A microcontroller is a compact integrated circuit designed to govern a specific operation in an embedded system. It combines a CPU, memory (RAM/ROM), and programmable input/output (I/O) pins on a single chip.

Arduino Uno

- **ATmega328P** Microprocessor
- 14 Digital I/O Pins (Pins 0-13)
- 6 Analog Input Pins (A0-A5)
- 5V Operating Voltage
- Programmable via C/C++ (Arduino IDE)

BBC micro:bit

- **Built-in Accelerometer:** Detects motion, tilt, and shake.
- **5x5 LED Matrix:** Visual output display.
- **Compass & Temperature Sensor:** Environmental sensing.
- 2 Push buttons (A & B)
- Programmable via Block-based MakeCode or Python.

2. Arduino Key Functions & Pins

Function Syntax	Mode / Range	Purpose & Description
`pinMode(pin, mode);`	`INPUT` / `OUTPUT`	Configures specified pin to behave either as an input (reading sensors) or output (driving LEDs/motors).
`digitalWrite(pin, value);`	`HIGH` (5V) / `LOW` (0V)	Outputs a digital HIGH or LOW voltage to a specified digital pin.
`analogRead(pin);`	**0 to 1023** (10-bit ADC)	Reads voltage level (0V to 5V) on an analog input pin (A0-A5) and converts it into an integer between 0 and 1023.
`analogWrite(pin, value);`	0 to 255 (PWM)	Outputs a Pulse Width Modulation signal to simulate variable analog output (e.g., motor speed control).

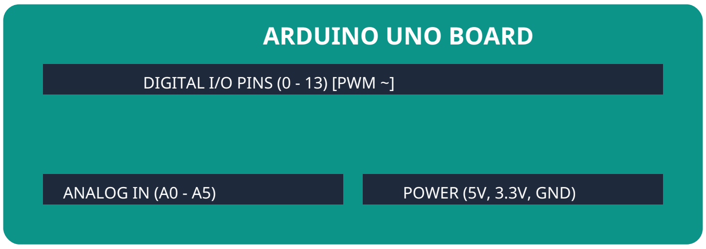


Figure 6.1: Arduino Uno Pin Layout Map

SECTION 7: PROTOTYPING WITH TINKERCAD & BREADBOARDS

1. Breadboard Internal Connection Mechanics

A breadboard allows students to prototype electronic circuits safely without soldering.

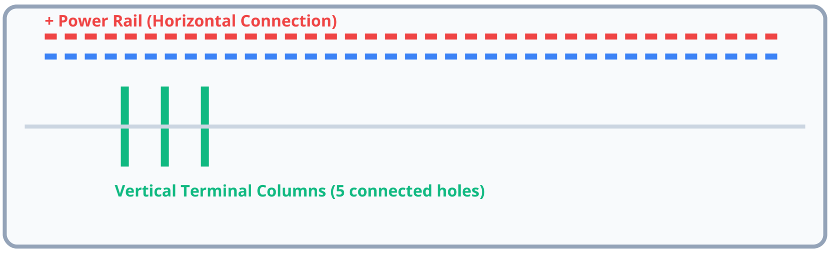


Figure 7.1: Internal Connections of a Solderless Breadboard

2. Benefits of Tinkercad Circuit Simulation

- **Risk-Free Learning:** Test circuits without blowing real components or microcontrollers due to overcurrent/ short circuits.
- **Cost Optimization:** Zero component damage or material expenditure during the design phase.
- **Real-time Debugging:** View simulated voltage/current levels and code execution live.

SECTION 8: DESIGN CHALLENGE - AUTOMATIC IRRIGATION SYSTEM

1. Problem Brief

Farmers lose crops due to over- or under-watering. You must design an automated irrigation system using an **Arduino Uno**, a **Soil Moisture Sensor**, a **5V Water Pump (DC Motor)**, and a **Status LED**.

2. System Architecture & Wiring Configuration

Pin Allocation Table

Component	Arduino Pin	Config Mode
Moisture Sensor	A0 (Analog)	INPUT
Water Pump (via Transistor)	Pin 9 (Digital)	OUTPUT
Alert LED	Pin 13 (Digital)	OUTPUT

Irrigation Decision Logic

```
val = analogRead(A0);
if (val < 400) { // Soil is Dry
  digitalWrite(9, HIGH); // Pump ON
  digitalWrite(13, HIGH); // LED ON
} else { // Soil is Moist
  digitalWrite(9, LOW);  // Pump OFF
  digitalWrite(13, LOW);  // LED OFF
}
```

3. System Decision Flowchart

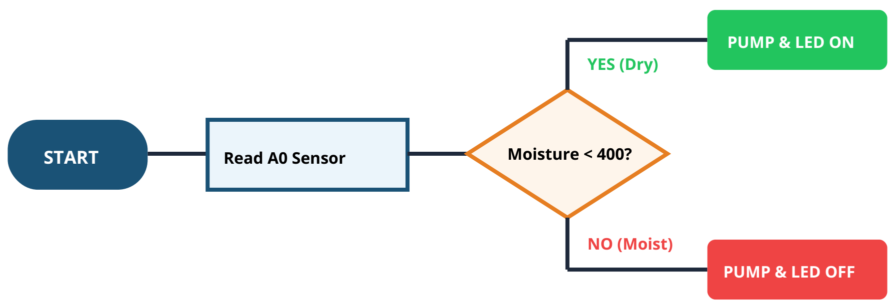


Figure 8.1: Decision-Making Logic Flowchart for Automatic Irrigation Controller

SECTION 9: PRACTICE EXAMINATION PAPER

TOTAL MARKS: 50 | TIME: 1 HOUR

SECTION A: MULTIPLE CHOICE (10 Marks)

1.1 Two $10\ \Omega$ resistors are connected in parallel. What is their total combined resistance? (1)

A) $20\ \Omega$ B) $10\ \Omega$ C) $5\ \Omega$ D) $2.5\ \Omega$

1.2 Which component is specifically designed to convert mechanical rotational energy into electrical energy? (1)

A) Electric Motor B) Generator C) Potentiometer D) Solenoid

1.3 What value range does the Arduino function `analogRead()` return? (1)

A) 0 to 255 B) 0 to 1023 C) HIGH or LOW D) 0V to 12V

1.4 In a parallel circuit, if one bulb blows/fails, what happens to the remaining bulbs? (1)

A) They turn off B) They stay lit C) They dim D) They burn out

1.5 Which feature is built directly into the BBC micro:bit to detect physical tilt and movement? (1)

A) Potentiometer B) Accelerometer C) Ultrasonic Sensor D) LDR

1.6 Which formula correctly expresses Electrical Power (P) in terms of current and resistance? (1)

A) $P = I \times R$ B) $P = I^2 \times R$ C) $P = V \div I$ D) $P = I \div R^2$

1.7 Unwanted energy in electrical circuits is most commonly wasted as which form of energy? (1)

A) Light B) Sound C) Heat D) Chemical

1.8 An ammeter must always be connected in _______ with the circuit component. (1)

A) Parallel B) Series C) Reverse D) Direct

1.9 What is the primary function of a breadboard in electronics? (1)

A) Permanent soldering B) Rapid prototyping C) Power storage D) Voltage step-up

1.10 An electric motor operates on which underlying physical effect? (1)

A) Thermionic emission B) Motor Effect C) Photovoltaic Effect D) Static friction

SECTION B: MATCHING COLUMNS (5 Marks)

Match the item in Column A with the correct description in Column B. Write only the letter (A-E) next to the question number (2.1–2.5).

Column A	Column B
2.1 Potentiometer	A. Device converting electrical energy into mechanical movement.
2.2 Commutator	B. Reverses current direction in motor armature every half-turn.
2.3 Digital Output	C. Variable resistor used to control current or voltage manually.
2.4 Efficiency	D. Signal having only two distinct states: HIGH (5V) or LOW (0V).
2.5 Electric Motor	E. Ratio of useful output energy to total input energy expressed as %.

SECTION C: DEFINITIONS (10 Marks)

Define the following key technical terms clearly and precisely:

3.1 Parallel Circuit (2)

3.2 Electromagnetic Induction (2)

3.3 Microcontroller (2)

3.4 Efficiency (2)

3.5 Ohm's Law (2)

SECTION D: CIRCUIT DIAGRAMS & ANALYSIS (10 Marks)

4.1 Draw a neat, labeled circuit diagram containing a **12V battery**, a **closed switch**, an **Ammeter**, and two resistors ($R_1 = 12\ \Omega$, $R_2 = 6\ \Omega$) connected in **PARALLEL**. Connect a **Voltmeter** across resistor R_1. (5)

4.2 Calculate the total parallel resistance (R_T) for the circuit above. (3)

4.3 Explain briefly why the total resistance of two parallel resistors is always smaller than the value of the smallest individual resistor. (2)

SECTION E: CALCULATIONS (10 Marks)

Show all formula steps, substitutions, and final units for the following problems:

5.1 A **240 V** electrical appliance draws a current of **5 A**. Calculate its power rating in Watts (W). (2)

5.2 If a motor receives **500 W** of input power and provides **400 W** of useful mechanical output, calculate its efficiency percentage. (3)

5.3 Calculate how much electrical energy in Joules (J) a **100 W** light bulb consumes when left on for **3 minutes**. (3)

5.4 Calculate the heat power dissipated by a $4\ \Omega$ resistor carrying a current of $3\ A$. (2)

SECTION F: DESIGN APPLICATION CHALLENGE (5 Marks)

Refer to the Automatic Irrigation System design in Section 8:

6.1 Explain why the soil moisture sensor must be connected to an **Analog Input pin** (A0) rather than a Digital Input pin. (2)

6.2 State two distinct advantages of testing this system on **Tinkercad Circuits** before purchasing real electronic components. (2)

6.3 Suggest one power-saving strategy to reduce energy consumption in a solar-powered field installation. (1)

SECTION 10: FULL MEMORANDUM & ANSWER KEY

SECTION A: MULTIPLE CHOICE

1.1 **C** ($R_T = 10 \div 2 = 5\ \Omega$) (1)

1.2 **B** (Generator converts mechanical to electrical) (1)

1.3 **B** (10-bit ADC gives values from 0 to 1023) (1)

1.4 **B** (Parallel branches operate independently) (1)

1.5 **B** (Accelerometer senses tilt/acceleration) (1)

1.6 **B** ($P = I^2R$) (1)

1.7 **C** (Heat generated via internal resistance) (1)

1.8 **B** (Ammeters must be in series to measure full current) (1)

1.9 **B** (Prototyping without soldering) (1)

1.10 **B** (Current in magnetic field experiences force) (1)

SECTION B: MATCHING COLUMNS

2.1 **C** | 2.2 **B** | 2.3 **D** | 2.4 **E** | 2.5 **A** (5 Marks)

SECTION C: DEFINITIONS

3.1 **Parallel Circuit:** A circuit configuration where components are connected across multiple branches, providing more than one path for current flow. (2)

3.2 **Electromagnetic Induction:** The process of generating an electric current/voltage across a conductor by moving it through a magnetic field. (2)

3.3 **Microcontroller:** A compact integrated circuit containing a processor, memory, and input/output pins designed to perform dedicated automated tasks. (2)

3.4 **Efficiency:** The percentage ratio of useful output energy/power produced by a system compared to the total input energy/power supplied. (2)

3.5 **Ohm's Law:** The physical law stating that voltage across a conductor is directly proportional to current flowing through it, provided physical conditions remain constant ($V = IR$). (2)

SECTION D: CIRCUIT DIAGRAMS & ANALYSIS

4.1 Diagram Checklist: Correct symbols for 12V Battery (1), Closed Switch (1), Ammeter in Series (1), Parallel Branches with R_1 & R_2 (1), Voltmeter in Parallel across R_1 (1). Total: (5)

4.2 $R_T = (R_1 \times R_2) \div (R_1 + R_2) = (12 \times 6) \div (12 + 6) = 72 \div 18 = 4\ \Omega$ (3 Marks: Formula, Substitution, Final Answer with Unit)

4.3 Adding parallel branches creates additional alternative pathways for electrons to flow, increasing total current flow and thus reducing net total circuit resistance. (2)

SECTION E: CALCULATIONS

5.1 $P = V \times I = 240\ V \times 5\ A = 1200\ W$ (or 1.2 kW) (2)

5.2 $Efficiency = (400 \div 500) \times 100 = 80\%$ (3)

5.3 $t = 3 \times 60 = 180\ s$
$E = P \times t = 100\ W \times 180\ s = 18\ 000\ J$ (or 18 kJ) (3)

5.4 $P = I^2 \times R = (3)^2 \times 4 = 9 \times 4 = 36\ W$ (2)

SECTION F: DESIGN APPLICATION

6.1 Soil moisture levels vary continuously across a spectrum (analog values), requiring continuous reading (0-1023) rather than a simple binary ON/OFF signal (digital). (2)

6.2 (1) Prevents burning real microcontrollers/pumps during wiring mistakes. (2) Zero financial cost to iterate and debug code prior to physical build. (2)

6.3 Program the Arduino to enter deep sleep mode and only wake up every 30 minutes to sample moisture levels. (1)

SECTION 11: GLOSSARY & QUICK REFERENCE CARDS

Glossary of Key Terms

Term	Definition
Ammeter	Instrument connected in series to measure electrical current in Amperes.
Analog Signal	A continuous signal with infinite possible values within a given range.
Armature	The rotating coil component of an electric motor or generator.
Commutator	A rotary switch that reverses current direction in an armature coil.
Digital Signal	A discrete signal having only two states: HIGH (1) or LOW (0).
Potentiometer	A three-terminal variable resistor used to adjust electrical output.
Voltmeter	Instrument connected in parallel to measure potential difference in Volts.

Printable Quick Reference Formula Cards

CARD 1: OHM'S LAW & POWER

- $V = I \times R$ | $I = V \div R$ | $R = V \div I$
- $P = V \times I$ | $P = I^2 \times R$ | $P = V^2 \div R$
- Units: Voltage (V), Current (A), Resistance (Ω), Power (W)

CARD 2: ENERGY & EFFICIENCY

- $E = P \times t$ (Energy in Joules J, time in seconds s)
- $Efficiency = (Useful\ Output \div Total\ Input) \times 100$
- Parallel Resistance: $R_T = (R_1 \times R_2) \div (R_1 + R_2)$

EXCELLENCE IN TECHNOLOGY

"Technology is best when it brings people together and solves real-world challenges."

STUDENT NOTES & REMINDERS:

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