Worked Solutions for ENGAA Papers by Topic

Section 1

Topic: Electricity

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ENGAA S1 2020 - Question 5

5 A dc electricity transmission system uses an undersea cable to send electricity from one country to another. On a particular day, the first country supplies electricity at a voltage of 400 kV and 2000 A to the transmission system. The second country receives electricity from the transmission system at 160 kV and 4000 A.

What is the percentage efficiency of the system and how much energy is wasted every minute?

	efficiency %	*energy wasted every minute / J*
A	20	9.6×10^9
B	20	3.84×10^{10}
C	20	4.8×10^{10}
D	80	9.6×10^9
E	80	3.84×10^{10}
F	80	4.8×10^{10}

ENGAA S1 2020 - Question 5 - Worked Solution

$$P = IV$$
$$P_{in} = 8 \times 10^8$$
$$P_{out} = 6.4 \times 10^8$$
$$(8 - 6.4) \times 10^8 \times 60s$$
$$= 9.6 \times 10^9 Jmin^{-1}$$
$$Efficiency = \frac{P_{out}}{P_{in}} \times 100 = 80\%$$

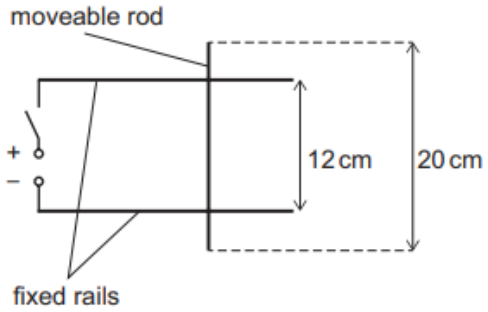
Answer is D

ENGAA S1 2020 - Question 7

7 Two fixed horizontal metal rails are side by side and 12 cm apart. The rails are connected to a dc power supply by a switch that is initially open.

A freely moveable metal rod of length 20 cm is placed on the rails as shown in the diagram. The diagram shows the arrangement seen from above.

The angle between the rod and the rails is 90°.



The whole arrangement is placed in a uniform magnetic field of magnitude 0.50 T that is directed perpendicularly into the page.

The moveable rod has a weight of 0.40 N.

The switch is now closed. As a result, there is a current of 2.4 A in the circuit and the rod moves.

What is the initial magnitude of the acceleration of the rod and what is its direction?

(gravitational field strength = 10 N kg^{-1})

	acceleration / m s^{-2}	*direction*
A	0.36	to the left
B	0.36	to the right
C	0.60	to the left
D	0.60	to the right
E	3.6	to the left
F	3.6	to the right
G	6.0	to the left
H	6.0	to the right

ENGAA S1 2020 – Question 7 - Worked Solution

$$F = ma = BIl$$

$$a = \frac{BIl}{m}$$

$$a = 3.6ms^{-2}$$

$$From\ left\ hand\ rule$$

$$F = I.B \times h$$

Thus force to right

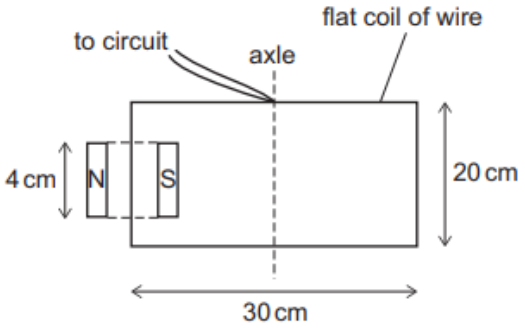
Answer is F

ENGAA S1 2020 - Question 27

27 A flat rectangular coil of wire with sides of length 30 cm and 20 cm is freely pivoted about an axle. The axle passes through the middle of the sides of length 30 cm.

Part of the coil is between the poles of a U-shaped magnet as shown in the diagram. The poles are 4.0 cm long. The magnetic field can be considered uniform between the poles, and zero elsewhere.

The coil is connected to a power supply so that there is a current in it.



[diagram not to scale]

The current is 0.60 A and the magnetic flux density is 0.050 T. There are 50 turns of wire in the coil.

What is the moment about the axle, in N cm, produced by the magnetic force acting on the coil?

A 0.018 N cm

B 0.036 N cm

C 0.045 N cm

D 0.90 N cm

E 1.8 N cm

F 2.25 N cm

G 4.5 N cm

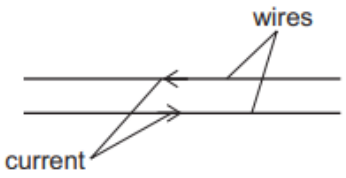
ENGAA S1 2020 - Question 27 - Worked Solution

$$F = BIl$$
$$J = F.d$$
$$J = BIl.d$$
$$J = 0.05 \times 0.6 \times (4 \times 10^{-2} \times 50) \times 15$$
$$J = 0.90Ncm$$

Answer is D

ENGAA S1 2020 - Question 31

31 Electrical power is supplied through a dc transmission line that consists of two metal wires. Each wire is 8.0 km long and has a cross-sectional area of 1.0 cm^2.



The resistivity of the metal from which the wires are made is $2.5 \times 10^{-7}\,\Omega\,m$.

Electrical power is transmitted to the transmission line at a potential difference of 24 000 V.

At what rate is energy being wasted as heat in the wires when the power supplied to the transmission line is 120 kW?

A 0.40 W

B 0.80 W

C 1.6 W

D 250 W

E 500 W

F 1000 W

G 1.44×10^7 W

H 5.76×10^7 W

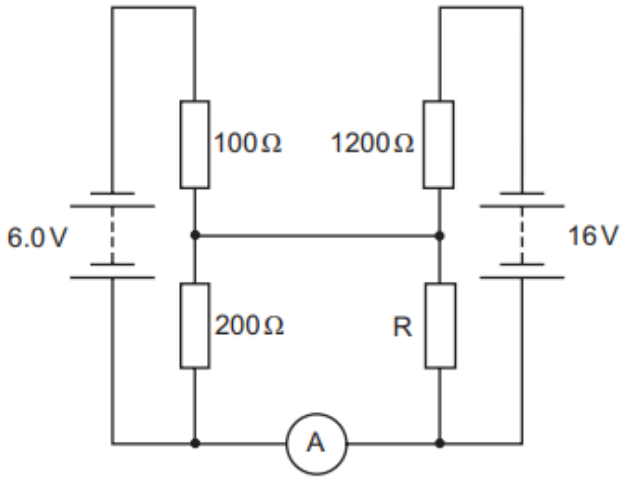
ENGAA S1 2020 - Question 31 - Worked Solution

$$P = \frac{RA}{l} \rightarrow R = 40\Omega$$
$$P = IV \rightarrow I = 5A$$
$$P_{disipated} = I^2R = 1000W$$

Answer is F

ENGAA S1 2020 - Question 39

39 In the following circuit, the ammeter records a current of zero.



What is the resistance of resistor R?

A 0Ω

B 200Ω

C 300Ω

D 400Ω

E 600Ω

F 1200Ω

G 1800Ω

H 2400Ω

ENGAA S1 2020 - Question 39 - Worked Solution

$$for \quad I_0 = 0 \ , v_1 = v_2$$

$$\frac{3000}{200+100}.6 = \frac{R}{1200+R}.16$$

$$4(1200+R) = 16R$$

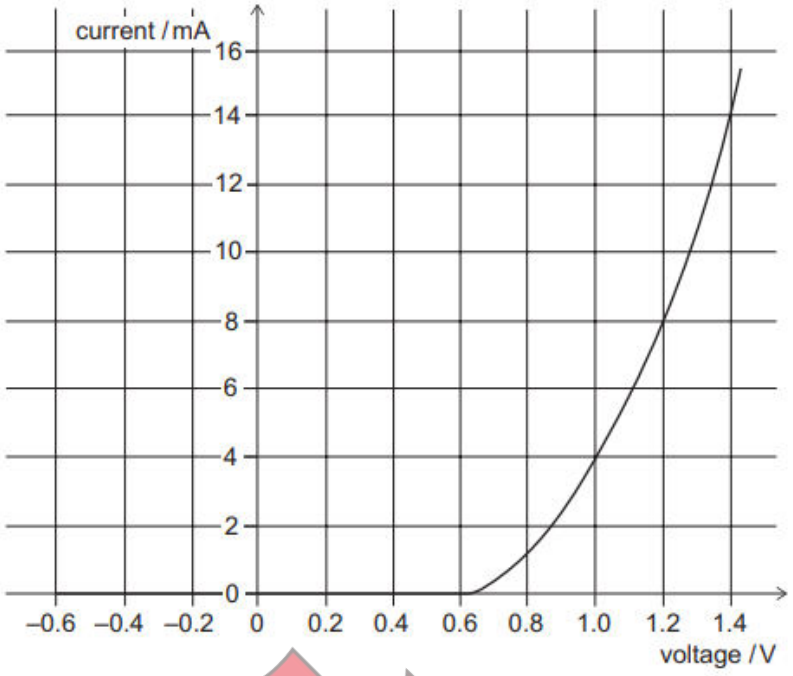
$$12R = 4800\Omega$$

$$R = 400\Omega$$

Answer is D

ENGAA S1 2019 - Question 2

2 The current–voltage graph for a diode is shown.



The diode is connected in series with a resistor and a 6.0 V battery. The current in the circuit is 8.0 mA.

What is the resistance of the resistor?

(Assume that the battery has negligible resistance.)

A 0.15 Ω

B 0.60 Ω

C 0.75 Ω

D 4.8 Ω

E 150 Ω

F 600 Ω

G 750 Ω

ENGAA S1 2019 - Question 2 - Worked Solution

$$V = IR \quad \rightarrow R = \frac{V}{I}$$
$$I = 8mA$$

$$V = 1.2V$$
$$V_{res} = 6V - 1.2V = 4.8$$
$$R = \frac{4.8V}{8mA} = 600\Omega$$

Answer is F

ENGAA S1 2019 - Question 8

8 The secondary coil of an ideal, 100% efficient transformer is connected to a resistor by cables of total resistance 1500 Ω. The current in the primary coil is 4.0 A. There are 240 turns in the primary coil and 4800 turns in the secondary coil.

What is the power produced as heat in the cables?

A 60 W

B 300 W

C 6000 W

D 24 000 W

E 120 000 W

F 9 600 000 W

ENGAA S1 2019 - Question 8 - Worked Solution

$$I_P = 4A \rightarrow I_S = \frac{240}{4500} . 4A = 0.2A$$

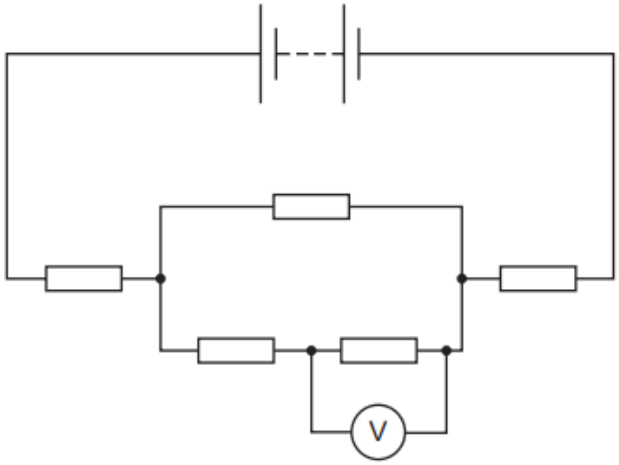
$$P = I^2R = (0.2)^2 . 1500\Omega$$

$$P = 60W$$

Answer is A

ENGAA S1 2019 - Question 16

16 In the following circuit, all five resistors have the same resistance.



The reading on the voltmeter is 1.0 V.

What is the voltage across the battery?

A 4.0 V

B 5.0 V

C 6.0 V

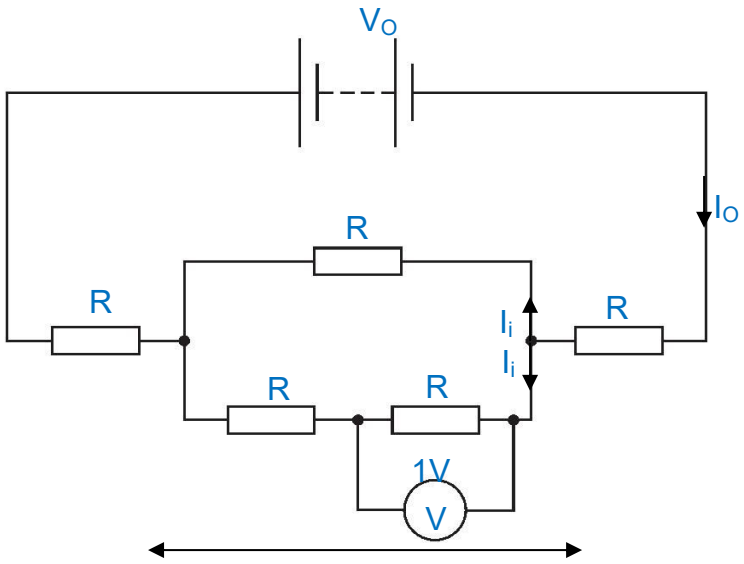
D 7.0 V

E 8.0 V

F 9.0 V

G 10 V

ENGAA S1 2019 - Question 16 - Worked Solution



Parallel branch

$$R' = \left(\frac{1}{R} + \frac{1}{2R}\right)^{-1}$$

$$R' = \frac{2}{3}R$$

$$V_{parallel} = 2V$$

$2V$ *measured across parallel branch*

By potential divider formula

$$2V = \frac{\frac{2}{3}R}{\frac{2}{3}R + 2R} - V_0$$

$$V_0 = 8V$$

Answer is E

ENGAA S1 2019 - Question 26

26 A metal wire of length 0.50 m has a uniform cross-sectional area of $4.0 \times 10^{-7}\,m^2$.

There is a current of 4.0 A in the wire.

What is the potential difference across the ends of the wire?

(resistivity of the metal = $1.6 \times 10^{-7}\,\Omega m$)

A 0.05 V

B 0.20 V

C 0.80 V

D 3.2 V

E 5.0 V

F 20 V

ENGAA S1 2019 - Question 26 - Worked Solution

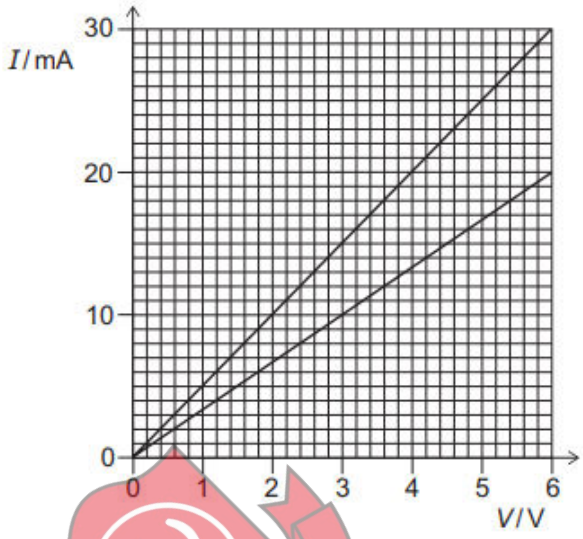
$$\rho = \frac{RA}{l} \rightarrow R = \frac{\rho l}{A} = 0.8V$$

Answer is C

ENGAA S1 2019 - Question 34

34 A student has one 300 Ω resistor and another resistor of resistance *R*.

The student plots a graph of current *I* against potential difference *V* for the 300 Ω resistor and then for both resistors connected in parallel.



What is the resistance *R*?

A 3.3 Ω

B 5.0 Ω

C 10 Ω

D 100 Ω

E 200 Ω

F 600 Ω

G 1000 Ω

ENGAA S1 2019 - Question 34 - Worked Solution

$$V = IR$$

$$R = \frac{V}{I}$$

$$\frac{6V}{30 \times 10^{-3} mA} = 200\Omega$$

$$R' = \left(\frac{1}{R} + \frac{1}{300}\right)$$

$$R' = 200\Omega = \left(\frac{1}{R} + \frac{1}{300}\right)$$
$$\frac{1}{R} = \frac{1}{200} - \frac{1}{300} = \frac{100}{60000}$$
$$R = 600\Omega$$

Answer is F

ENGAA Specimen S1 - Question 6

6 Which of the following is a correct unit of potential difference (voltage)?

A amp per ohm

B coulomb per joule

C joule per second

D newton per coulomb

E watt per amp

ENGAA Specimen S1 - Question 6 - Worked Solution

$$E = QV \quad , \quad V = IR \, , \quad P = IV$$

Write out equations that use voltage

Look at the units and see what correspond to possible answers.

$$V = \frac{P}{I} \Rightarrow \frac{Watt}{Amp}$$

Answer is E

ENGAA Specimen S1 – Question 18

18 Two resistors with resistance R_1 ohms and R_2 ohms are connected in series with a battery that has a voltage V across its terminals.

Which formula gives the power dissipated by the resistor with resistance R_1 ohms?

A $\dfrac{VR_1}{R_1+R_2}$

B $\dfrac{V^2R_1}{R_1+R_2}$

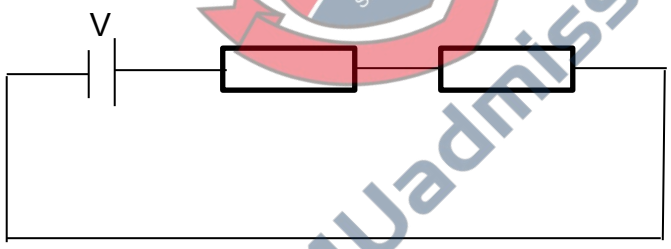
C $\dfrac{VR_1}{(R_1+R_2)^2}$

D $\dfrac{V^2R_1}{(R_1+R_2)^2}$

E $\dfrac{VR_1^2}{(R_1+R_2)}$

F $\dfrac{V^2R_1^2}{(R_1+R_2)^2}$

ENGAA Specimen S1 - Question 18 - Worked Solution



$$R_T = R_1 + R_2$$

$$I = \frac{V}{R_T}$$

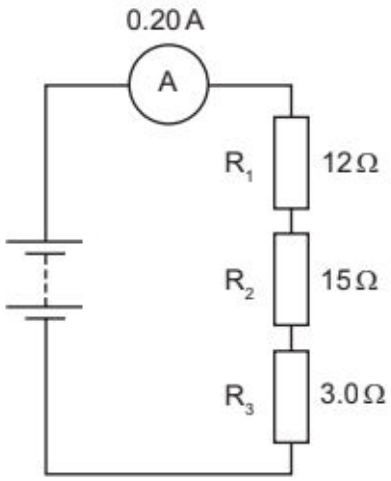
$$P_1 = I^2 R_1$$

$$P_1 = \frac{V^2}{(R_1+R_2)^2} R_1$$

Answer is D

ENGAA S1 2018 - Question 4

4 The diagram shows three resistors R_1, R_2 and R_3 connected in series with a battery of constant voltage. The resistance of each resistor and the corresponding current are also shown.



Resistor R_3 is now removed and the circuit is reconnected.

What is the new current in the circuit?

A 0.20 A

B 0.22 A

C 0.33 A

D 0.40 A

E 0.50 A

F 2.0 A

G 6.0 A

ENGAA S1 2018 - Question 4 - Worked Solution

$$R_T = R_1 + R_2 + R_3 = 30\Omega$$
$$V = IR$$
$$= 0.2 \times 30$$
$$= 6$$

ENGAA S1 2018 - Question 10

10 The potential difference across the motor in an electric car is 400 V and the current in the motor is 1250 A.

The car accelerates along a horizontal road from rest for 4.0 s.

The efficiency of the overall system is 45%.

What is the kinetic energy of the car at the end of the 4.0 s?

(Ignore energy losses due to air resistance and due to friction between the tyres and the road.)

A 225 000 J

B 500 000 J

C 900 000 J

D 1 250 000 J

E 2 000 000 J

ENGAA S1 2018 - Question 10 - Worked Solution

Total energy from motor:

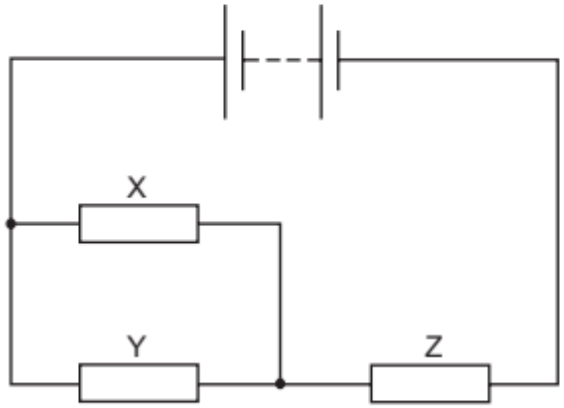
$$E = Pt$$
$$W = IVt$$
$$E = 400 \times 125 \times 4$$
$$E = 200000J$$
$$Useful\ energy = 0.45E$$
$$= 900000J$$
$$= KE$$

(As ignoring energy lost to air resistance and friction)

Answer is C.

ENGAA S1 2018 - Question 26

26 The diagram shows a circuit containing a battery and three identical resistors X, Y and Z.



The total power supplied by the battery is 18 W.

What is the power dissipated as heat in resistor X?

A 1.5 W

B 2.0 W

C 3.0 W

D 4.5 W

E 6.0 W

F 8.0 W

G 12 W

ENGAA S1 2018 - Question 26 - Worked Solution

$$R_T = \left(\frac{1}{R} + \frac{1}{R}\right)^{-1} + R$$

$$= \frac{R}{2} + R$$

$$= \frac{3R}{2}$$

$$P = I^2 R$$

$$= \frac{I^2 \times 3R}{2} = 18$$

$$I^2 R = 12$$

X and Y have same V and R

$$I_1 = I_2$$

$$I = I_1 + I_2$$

$$I_1 = \frac{I}{2}$$

So power dissipated in X is:

$$P_x = R{I_1}^2$$
$$= \frac{I^2}{4}R$$
$$= \frac{12}{4}$$
$$= 3W$$

Answer is C.

ENGAA S1 2017 - Question 20

20 A kettle is designed to work from a car's power socket. The kettle has a power rating of 150 W when a constant voltage of 12.0 V d.c. is applied across its element.

How much charge passes through the element of this kettle when the voltage of 12.0 V is applied across it for 20 minutes?

A 96 C

B 250 C

C 15 000 C

D 36 000 C

E 900 000 C

F 2 160 000 C

ENGAA 2017 - Question 20 - Worked Solution

$$P = IV$$
$$\Rightarrow I = \frac{P}{V} = \frac{150}{12} = 12.5A$$
$$Q = It$$
$$= 12.5 \times 20 \times 60$$
$$= 15000\ C$$

Answer is C

ENGAA S1 2016 - Question 8

8 A circuit consists of a 5.0 Ω resistor and a variable resistor connected in series with a 24 V battery. The variable resistor has a minimum resistance of 3.0 Ω and a maximum resistance of 15 Ω. The battery and the connecting wires have negligible resistance.

What is the maximum power dissipated in the 5.0 Ω resistor?

A 7.2 W

B 18 W

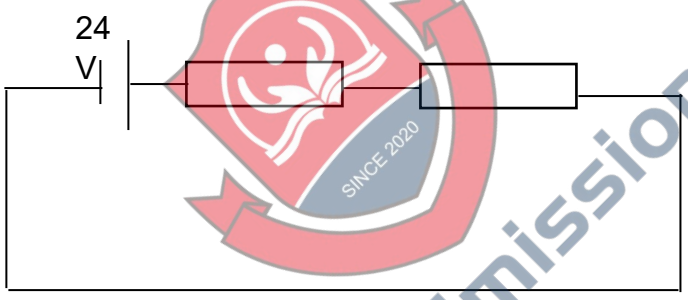
C 27 W

D 45 W

E 72 W

F 75 W

ENGAA S1 2016 - Question 8 - Worked Solution



$$3.0 \leq R \leq 15.0$$

For the maximum power in the 5.0Ω resistor, find the maximum voltage across it

By Kirchoff's voltage law the sum of voltages across the resistors will be 24V

$$V_i = V_{in}\frac{R_i}{R_T}$$

For maximum voltage across 5Ω resistor, $\frac{5}{R_T}$ must be maximum so the variable resistor must have the minimum resistance

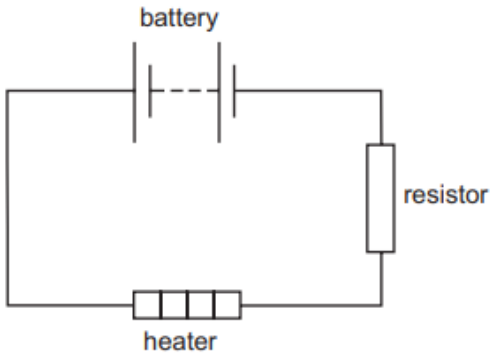
$$V_1 = 24 \times \frac{5}{8} = 15V$$

$$P = \frac{V^2}{R} = 45W$$

Answer is D

ENGAA S1 2016 - Question 16

16 A heater is connected in series with a resistor and a 6.0 V battery in the circuit shown.



The total resistance of the circuit is 15 Ω. In 3.0 minutes, 180 J of electrical energy is transferred into other forms in the heater.

How much charge flows through the heater in the 3.0 minutes and what is the voltage across the heater?

	charge / C	*voltage* / V
A	1.2	150
B	1.2	216
C	7.5	0.041
D	7.5	24
E	72	0.40
F	72	2.5
G	450	0.40
H	450	2.5

ENGAA S1 2016 - Question 16 - Worked Solution

The heater is R_1

$$P = \frac{V^2}{R} = \frac{\Delta E}{\Delta t}$$

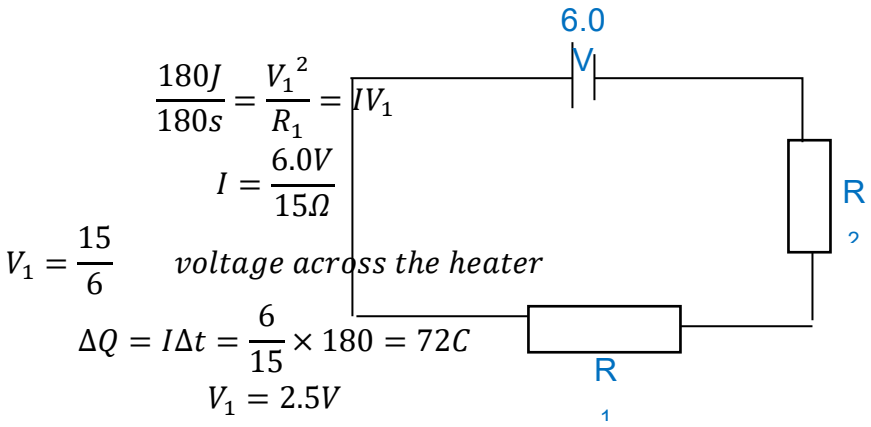
$$\frac{180J}{180s} = \frac{V_1{}^2}{R_1} = IV_1$$

$$I = \frac{6.0V}{15\Omega}$$

$V_1 = \frac{15}{6}$ *voltage across the heater*

$$\Delta Q = I\Delta t = \frac{6}{15} \times 180 = 72C$$

$$V_1 = 2.5V$$



Answer is F