11.2 Power Generation & Transmission

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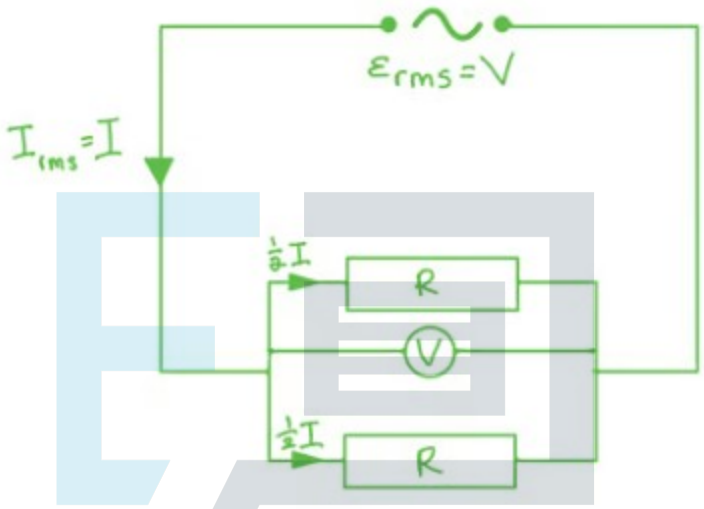
Course	DP IB Physics
Section	11. Electromagnetic Induction (HL only)
Topic	11.2 Power Generation & Transmission
Difficulty	Medium

To be used by all students preparing for DP IB Physics HL
Students of other boards may also find this useful

1

The correct answer is **B** because;

- List the known values:
  - Current from the supply, I_{rms} = I
  - Therefore current in each resistor = $\frac{1}{2}I_{rms}$ (because the current splits, see the circuit diagram below)



  - E.m.f. from the supply, ε_{rms} = V
- From the data booklet:
  - $P_{max} = I_0 V_0$ (equation 1)
  - $I_{rms} = \frac{I_0}{\sqrt{2}}$
  - $V_{rms} = \frac{V_0}{\sqrt{2}}$
- Therefore, for each resistor the current is determined by:
  - $I_0 = \frac{1}{2} I \sqrt{2}$ (because the current splits, as mentioned above - equation 2)
  - $V_0 = V\sqrt{2}$ (equation 3)
- Substituting equations 2 and 3 into equation 1:
  - $P_{max} = I_0 V_0$
  - $P_{max} = (\frac{1}{2} \times I \times \sqrt{2}) \times (V\sqrt{2})$

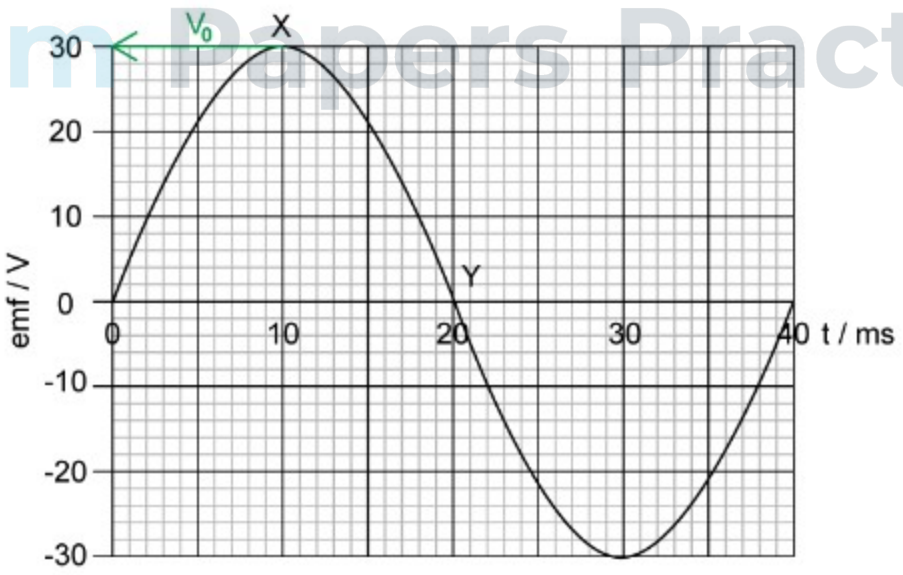
- Gathering like terms gives:
  - $P_{max} = \frac{1}{2}(I \times V) \times (\sqrt{2} \times \sqrt{2}) = IV$
  - Therefore, the correct answer is **B**

A is incorrect because	the rms values have been multiplied by $\sqrt{2}$ rather than divided
C is incorrect because	the values have been multiplied together incorrectly
D is incorrect because	the answer ignores the fact that the resistors are in parallel, so that current will be halved

2

The correct answer is **B** because;

- List the known values;
  - Resistance, $R = 10.0\ \Omega$
  - Peak voltage, $V_0 = 30\ V$ (from the graph)



- From the data booklet:
  - $P = \frac{V^2}{R}$ (from topic 5.2)
  - $\bar{P} = \frac{1}{2}P_{max}$
- Substitute the values;
  - $P = \frac{30 \times 30}{10} = 90$
- Average power, $\bar{P} = \frac{1}{2}P_{max}$
  - $\bar{P} = \frac{90}{2} = 45\,W$

A is incorrect as	90 is the maximum power, which must be divided by 2 to find the average power
C and **D** are incorrect as	dividing by √2 is using ideas from root mean square calculations (where √2 is important) where only peak values are being calculated

3

The correct answer is **C** because:

- List the known values;
  - $I_{rms} = 2I$
  - $V_{rms} = V$
- From the data booklet
  - $P_{max} = I_0 V_0$ (equation 1)
  - $I_{rms} = \frac{I_0}{\sqrt{2}}$
  - $V_{rms} = \frac{V_0}{\sqrt{2}}$
- Therefore:
  - $I_0 = I_{rms}\sqrt{2}$ (equation 2)
  - $V_0 = V_{rms}\sqrt{2}$ (equation 3)

- Substituting equations 2 and 3 into equation 1 shows that:
  - $P_{max} = I_0 V_0$
  - $P_{max} = (I_{rms}\sqrt{2}) \times (V_{rms}\sqrt{2}) = (2 \times I) \times V \times (\sqrt{2} \times \sqrt{2}) = 4IV$
- This is answer **C**

Sometimes you will have to use equations from other sections of the course: make sure you are able to apply these equations to a variety of question types.

4

The answer is **B** because:

- Increasing the speed of rotation increases the frequency, since the definition of frequency is the number of rotations per second
  - Therefore 3 × speed → 3 × frequency
  - Only **B** or **C** can be correct
- From the data booklet, $T = \frac{1}{f}$
  - Therefore since *f* has increased by a factor of three, time period will decrease to one third of the original value
- emf is defined as the rate of change of magnetic flux, $\varepsilon = \frac{\Delta \Phi}{t}$
  - Therefore, $\varepsilon \propto \frac{1}{t}$
  - Since $t = \frac{T}{3}$, ε must have increased by a factor of 3
- The correct answer is **B**

A and **D** are incorrect as	the new time period has been confused with the new frequency
C and **D** are incorrect as	the use of √2 shows that this was calculated for peak voltage but both the question and answer are looking at the rms value

5

The correct answer is **C** because:

- The question refers to an **ideal** transformer
  - In an ideal transformer there would be no losses due to heating
  - Therefore the **total power out is equal to the total power in**

How long did you spend solving this question? Sometimes examiners will throw you a curveball to see if you are listening!

The suggested answers for **A** and **B** imply that this could be complicated, but careful reading, and underlining key terms in the question - such as **ideal** - may get you there much quicker!

6

The correct answer is **D** because:

- Output voltage is proportional to the rate of change of magnetic flux, $\varepsilon \propto \frac{\Delta \Phi}{t}$
- Increasing the speed of rotation increases the rate of change
  - Therefore emf will **increase**
  - Only **B** or **D** can be correct as the **peaks** are **higher**
- The time period of the emf is proportional to the frequency of rotation
- Increasing the speed of rotation reduces time period, since $T = \frac{1}{f}$
  - The **number of waves** per time t **increases**
  - Only **D** can be correct

A and **C** are incorrect as	in these graphs emf peaks at the same value as in the question. In fact, doubling the speed of rotation will double the rate at which the magnetic flux changes, so the maximum emf also needs to doubles.
B is incorrect as	this graph has the same number of complete waves as in the question. Doubling the speed of rotation should have doubled the number of complete rotations per time.

7

The correct answer is **C** because:

- Power is related to voltage using $P_{max} = \frac{V^2}{R}$, from topic 5.2
  - This shows that power, $P \propto V^2$
- If voltage increases by a factor of 10^4, then power increases by a factor of $(10^4)^2$
  - Therefore power increases by a factor of 10^8

Remember that both the equations relating to power,

- $P = I^2R$

and

- $P = \frac{V^2}{R}$

are derived from the two equations:

- Ohm's law, where **V = IR**

and

- the equation for power, **P = VI**

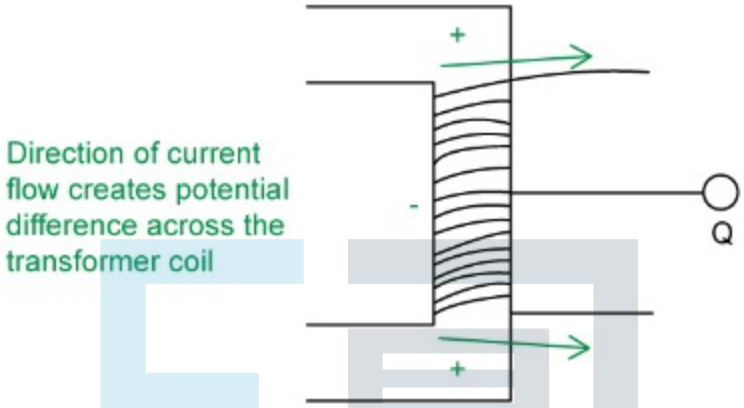
So you can use either one; they are interchangeable. You will need to check which values you already have to decide which version to use.

8

The correct answer is **C** because:

- The current from a transformer must be alternating current
  - With each cycle the current changes direction
  - The output end of the transformer coil is positive compared to the rest of the coil

- Therefore point P will always be positive compared to point Q and the emf between them will always have a positive value
    - Only **A** or **C** can be correct
- Since both diodes have forward bias, current will always flow
- The emf will be fully rectified
    - Only **C** can be correct



9

The correct answer is **A** because:

- To find frequency first find the **time period** from the graph
    - Each peak shows the coil being perpendicular to the field lines
    - Therefore one full rotation of the coil produces two peaks
- Therefore the graph shows that **time period of the rotation is 0.02 s**

- Frequency is found using;
    - $f = \frac{1}{T} = \frac{1}{0.02} = 50\ \text{Hz}$
    - Only **A** or **B** could be the correct answer

- To find average power dissipated in the resistor, first list the known values
    - Rms voltage, $V_{rms} = 120\ \text{V}$
    - Resistance, $R = 3.0\ \text{k}\Omega = 3000\ \Omega$

- From the data booklet
  - $P_{max} = \frac{V^2}{R}$ (topic 5.2)
  - $V_0 = \sqrt{2} \times V_{rms}$ (topic 11.2)
- Recall that **average** power is found by taking **half** of the maximum value:
  - $P_{average} = \frac{P_{max}}{2} = \frac{V^2}{2R}$
- Combining these shows that:
  - $P_{average} = \frac{(\sqrt{2} \times V_{rms})^2}{2R} = \frac{(\sqrt{2} \times 120)^2}{(2 \times 3000)} = 4.8\ \text{W}$
- Therefore, **A** must be the correct answer

B and **D** are incorrect because	the power is the peak value, but this must be halved to find the average value
C and **D** are incorrect because	time period has been found from one peak of the graph, rather than two

10

The correct answer is **D** because:

- Capacitors are the component required to provide smoothing of the output signal
  - When the output voltage is high the capacitor charges
  - When the output voltage falls, the capacitor discharges through the load
- Options **A** and **B** do not have a capacitor in the circuit so they cannot be correct

- The charge on a capacitor is directly proportional to the potential difference across it:
  - $q = CV$ (from the data booklet, topic 11.3)
- In option **C** the capacitor is connected in series with the resistor
  - This will **reduce** the potential difference across the capacitor as potential difference is shared
  - It will take on **less** charge and have **less** smoothing effect on the circuit
- In option **D** the capacitor is connected in parallel with the resistor
  - The capacitor will have the same potential difference as the output from the diode bridge
  - It will take on **more** charge and have the **greatest** effect on the circuit