

Exercise walk-through

14.1

Circuit power, induction and charged-particle motion

GRE · GRE Subject Test · GRE Physics

14.1 Circuit power, induction and charged-particle motion

Name: _____ Class: _____ Date: _____

Total: 11 marks

KEY WORDS root mean square • flux linkage

Objective

Solve resistor networks and distinguish rms from peak AC quantities; Apply flux linkage, Lenz direction and the current-loop field; Use charge-to-mass ratios and balance crossed-field forces. Original public practice; not an ETS paper.

1 Key knowledge and worked examples

Series resistances add; parallel conductances add. In the 24 V example, 3 Ω parallel 6 Ω gives 2 Ω . Adding series 2 Ω gives total 4 Ω and current 6 A. Branch voltage is 12 V, so currents are 4 A and 2 A. Check both Kirchhoff sums.

Sinusoidal $I_{\text{rms}} = I_{\text{max}}/\sqrt{2}$. Series RLC impedance is $\sqrt{R^2 + (\omega L - 1/(\omega C))^2}$, and average dissipated power is $I_{\text{rms}}^2 R = V_{\text{rms}} I_{\text{rms}} \cos \varphi$. Ideal L and C have zero average

dissipation. An ideal single diode gives half-wave pulses, with polarity set by orientation; do not halve rms power again.

Flux is $BA\cos\theta$ for uniform B , with θ from the area normal. Faraday emf is $-N \, d\Phi/dt$; perpendicular-field average magnitude is $NA|\Delta B|/\Delta t$. Lenz direction opposes the flux change. The centre field of a circular loop is $\mu_0 I/(2R)$, multiplied by N for a compact N -turn coil.

For nonrelativistic perpendicular motion, $r=mv/(|q|B)$ and cyclotron angular frequency $|q|B/m$. Charge sign sets rotation. Deuteron and alpha frequencies are each half the proton value at fixed B . A crossed-field selector requires opposing electric/magnetic forces and $v=E/B$.

■ Worked method

A 24 V ideal source drives 2 ohms in series with parallel 3 and 6 ohm branches. Identify nodes before reducing the network .

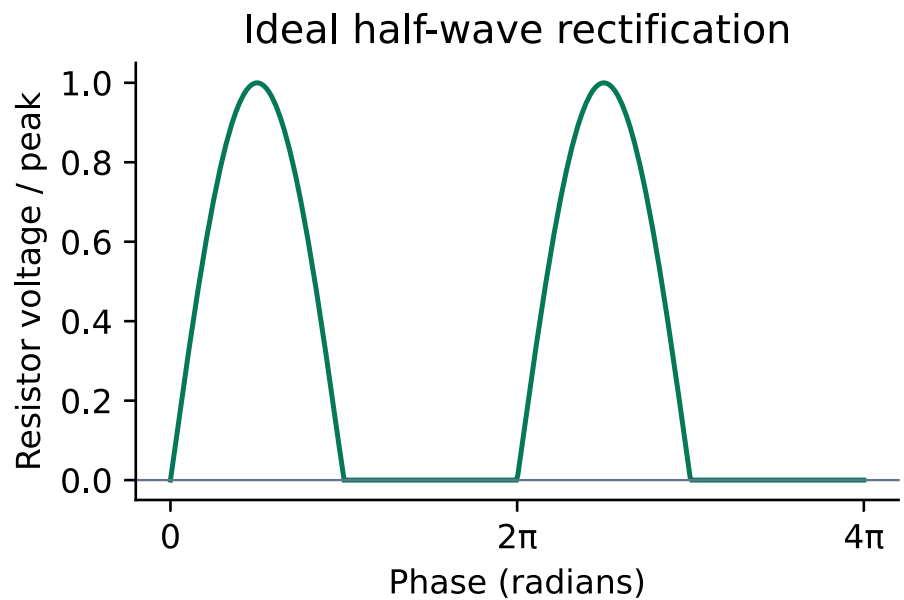
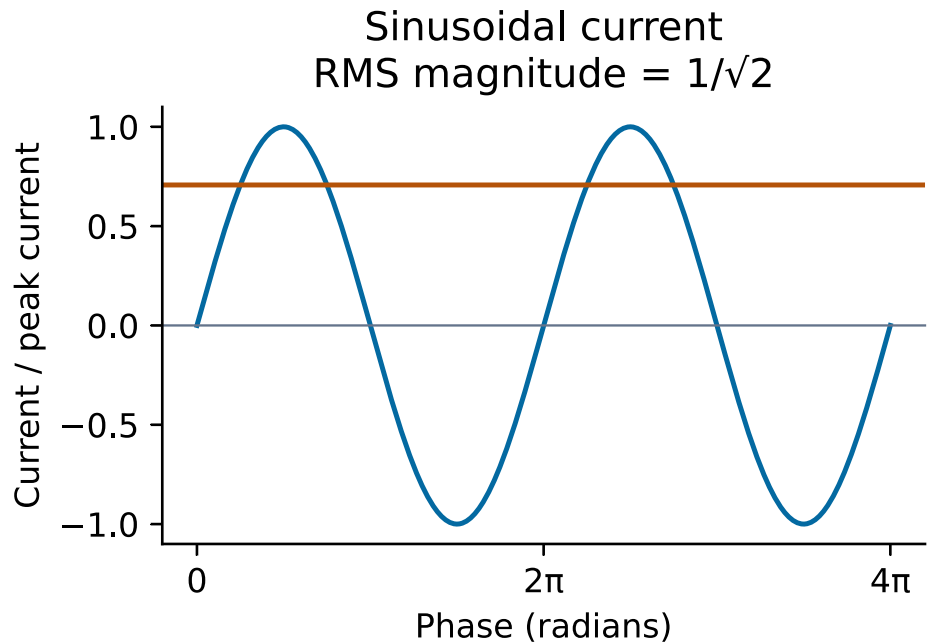
$$R_p = (1/R_1 + 1/R_2)^{-1} = (1/(3\ \Omega) + 1/(6\ \Omega))^{-1} = 2\ \Omega.$$

$$I = V/(R_s + R_p) = (24\ \text{V})/(4\ \Omega) = 6\ \text{A}.$$

$$V_p = IR_p = (6\ \text{A})(2\ \Omega) = 12\ \text{V}.$$

$$I_2 = V_p/R_2 = (12\ \text{V})/(6\ \Omega) = 2\ \text{A}.$$

The other branch carries 4 A; the branch currents sum to the source current.



Exercise 2.1

2.1 Choose one answer. In the worked 24 V resistor network, current through the $6\ \Omega$ branch is: [1]

- **A** 12 A
- **B** 6 A
- **C** 4 A
- **D** 2 A
- **E** 1 A

Exercise 2.1

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- **C** 4 A
- **D** 2 A
- **E** 1 A

2.1 D The parallel branches have 12 V, so the $6\ \Omega$ branch carries $12/6=2$ A.

Compare the rejected options: 12 A; 6 A; 4 A; 1 A. Use the stated model and conditions.

Exercises 2.2·2.3

2.2 Choose one answer. A series RLC circuit has $I_{\text{rms}}=3 \text{ A}$ and $R=4 \Omega$. Its average dissipated power is: [1]

- **A** 18 W
- **B** 36 W
- **C** 72 W
- **D** 12 W
- **E** 9 W

2.3 At fixed B, an ion with proton charge and three times proton mass has cyclotron frequency _____ times the proton frequency (fraction). Show your relation and units.[2]

Exercises 2.2-2.3

2.2 Choose one answer. A series RLC circuit has $I_{\text{rms}}=3$ A and $R=4\ \Omega$. Its average dissipated power is: [1]

- A 18 W
- B 36 W
- C 72 W
- D 12 W
- E 9 W

2.2 B $I_{\text{rms}}^2 R = 9 \cdot 4 = 36$ W; no extra half factor applies to rms current.

Compare the rejected options: 18 W; 72 W; 12 W; 9 W. Use the stated model and conditions.

2.3 At fixed B, an ion with proton charge and three times proton mass has cyclotron frequency _____ times the proton frequency (fraction). Show your relation and units.[2]

2.3 $1/3$. Angular frequency is $|q|B/m$.

Exercises 2.4·3.1

2.4 Decide whether this claim is true. Justify it: An ideal single series diode can convert an AC sine wave into positive half-wave pulses, but not full-wave pulses. [2]

3.1 A square N -turn loop of side a moves at speed v out of a uniform field B normal to its plane. Its total resistance is R . While one edge is crossing the straight field boundary, find the emf magnitude, current and required pulling force at constant speed. Verify mechanical input power equals resistor power. Neglect inductance. [5]

Exercises 2.4·3.1

2.4 Decide whether this claim is true. Justify it: An ideal single series diode can convert an AC sine wave into positive half-wave pulses, but not full-wave pulses. [2]

2.4 True. It conducts in one polarity and blocks in the other.

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3.1 Flux linkage changes at rate $NBav$, so $|\mathcal{E}| = NBav$ and $I = NBav/R$. The N edges still in the field give opposing force $F = NIaB = N^2B^2a^2v/R$. $Fv = N^2B^2a^2v^2/R = I^2R$; external work supplies the resistor heat. Lenz's law sets the force opposite motion. Award flux rate, emf/current, force, power check and direction. These results hold only during boundary crossing.