Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

Each answer shows the steps, then the **result**.

2.1

$\dfrac{dE}{dt} = \dfrac{1}{d}\dfrac{dV}{dt} = 1.0 \times 10^{9}$ V/(m · s); $I_d = \varepsilon_0 A \dfrac{dE}{dt} =$ **88.5 µA**; $C = \dfrac{\varepsilon_0 A}{d} = 88.5$ pF, and $C\dfrac{dV}{dt} = 88.5$ µA, the same

2.2

$\varepsilon = \dfrac{\Delta\Phi}{\Delta t} = \dfrac{25 \times 10^{-4} \times 0.060}{0.0050} =$ **30 mV**; $I = \dfrac{0.030}{10} =$ **3.0 mA**; the current makes its own field out of the page inside the loop, to oppose the fall: **anticlockwise** as seen

2.3

$\varepsilon = Blv = 0.50 \times 0.20 \times 4.0 = 0.40$ V, so $I =$ **0.20 A**; $F = BIl = 0.50 \times 0.20 \times 0.20 =$ **0.020 N**; $Fv = 0.080$ W $= I^2R = 0.20^2 \times 2.0$

2.4

$c = \dfrac{1}{\sqrt{4\pi \times 10^{-7} \times 8.854 \times 10^{-12}}} =$ **3.00 × 10⁸ m/s**; $v = \dfrac{c}{\sqrt{4.4}} = 1.43 \times 10^{8}$ m/s and $\lambda = \dfrac{v}{f} =$ **4.8 cm**; $\dfrac{\lambda}{10} =$ **4.8 mm**

3.1

$C = \dfrac{\varepsilon_0 \pi R^2}{d} =$ **69.5 pF**

$I_d = C\dfrac{dV}{dt}$, peak $C\omega V_0 = 69.5 \times 10^{-12} \times 2\pi \times 10^{6} \times 100 =$ **43.7 mA**

at $r = R$: $B = \dfrac{\mu_0 I_d}{2\pi R} =$ **0.175 µT**

at $r = 2.5$ cm, $B \propto r$ inside, so **0.087 µT**; B follows cos, so it leads V by 90°

3.2

$\omega = \dfrac{2\pi \times 3000}{60} = 314$ rad/s; $N\Phi = NBA\cos\omega t$

$\varepsilon = -\dfrac{d(N\Phi)}{dt} = NBA\omega\sin\omega t$; peak $50 \times 0.20 \times 0.010 \times 314 =$ **31.4 V**

at 30°: $31.4 \sin 30° =$ **15.7 V**

$P = \dfrac{V_{rms}^2}{R} = \dfrac{(31.4/\sqrt{2})^2}{10} =$ **49 W**

3.3

(a) $B = \dfrac{\mu_0 I}{2\pi r}$; $\Phi = \int_{2\text{ mm}}^{7\text{ mm}} \dfrac{\mu_0 I}{2\pi r}(0.010)\,dr = \dfrac{\mu_0 I (0.010)}{2\pi}\ln 3.5$; $M = \dfrac{\Phi}{I} = 2 \times 10^{-7} \times 0.010 \times 1.25 =$ **2.5 nH**

(b) $\varepsilon = M\dfrac{dI}{dt} = 2.5 \times 10^{-9} \times \dfrac{2.0}{20 \times 10^{-9}} =$ **0.25 V**, five times the signal

(c) $M = 2 \times 10^{-7} \times 0.010 \times \ln\dfrac{15}{10} = 0.81$ nH; $\varepsilon =$ **81 mV**

(d) no, 81 mV is still bigger than the signal; route the sensor's return wire right beside (or under) its signal wire, so the loop area and so the flux it catches are almost zero

exercises.lol exercises.com.cn