1. F = (x^2, y^2, z^2). What is $\nabla \cdot F$ at (1, 2, 3)?

   _____

2. A 1 nC point charge. What is E at 30 cm, in V/m?

   _____ V/m

3. When is Ampère's law the quick route to B?

   ☐ When symmetry makes B constant along a loop round the current

   ☐ Only for a single straight wire

   ☐ Always; Biot–Savart is never needed

   ☐ Only when the current changes

4. The minus sign in Faraday's law means the induced current

   ☐ opposes the change in magnetic flux

   ☐ adds to the change in flux

   ☐ always flows clockwise

   ☐ is zero in a conductor

5. In a plane wave in free space, E and B reach their peaks at the same moment.

   ☐ True ☐ False

6. A 10 cm PCB trace carrying a 1 kHz signal must be treated as a transmission line.

   ☐ True ☐ False

7. WR-90 waveguide is 22.86 mm wide. Its cutoff frequency is about

   ☐ 13.1 GHz

   ☐ 3.28 GHz

   ☐ 6.56 GHz

   ☐ 656 MHz

8. A static electric field has zero curl everywhere.

   ☐ True ☐ False

9. The field at the centre of a uniformly charged sphere is zero.

   ☐ True ☐ False

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_____ µT

1. **12**

   $\nabla \cdot \mathbf{F} = 2x + 2y + 2z = 2 + 4 + 6 = 12.$

2. **99.9 V/m**

   $E = \dfrac{q}{4\pi\varepsilon_0 r^2} = \dfrac{10^{-9} \times 8.99 \times 10^{9}}{0.09} = 99.9 \text{ V/m}.$

3. **When symmetry makes B constant along a loop round the current**

   The law always holds, but it gives B directly only when the loop integral reduces to $B\times$ length. Otherwise use Biot–Savart.

4. **opposes the change in magnetic flux**

   Lenz's law: if the induced current reinforced the change, energy would appear from nowhere.

5. **True**

   They are in phase in a lossless medium: $B = \dfrac{E}{c}$ at every point and time.

6. **False**

   At 1 kHz the wavelength is about 150 km in the board; 10 cm is a tiny fraction of it, so the voltage is effectively the same all along the trace.

7. **6.56 GHz**

   $f_c = \dfrac{c}{2a} = \dfrac{3 \times 10^{8}}{0.04572} = 6.56 \text{ GHz}.$

8. **True**

   With no changing magnetic field, $\nabla \times \mathbf{E} = 0$, which is why a potential V exists with $\mathbf{E} = -\nabla V$.

9. **True**

   $E = \dfrac{\rho r}{3\varepsilon_0}$ is zero at $r = 0$. By symmetry the pulls from all sides cancel there.

10. **40 µT**

    A circle round the wire: $B \cdot 2\pi r = \mu_0 I$, so $B = \dfrac{4\pi \times 10^{-7} \times 10}{2\pi \times 0.05} = 40\,\mu\text{T}.$

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