1. A proton is placed in a region of space where there is an electric field. The proton is then removed and an electron is put at the same place. Which answer best describes the forces felt by the proton and neutron?

\[ F_{\text{proton}} = F_{\text{electron}} \]

\[ F_{\text{proton}} = -F_{\text{electron}} \]

\[ F_{\text{proton}} > F_{\text{electron}} \]

\[ F_{\text{proton}} > F_{\text{electron}} \]

2. A charge is moved up and down at a frequency of 1,000,000 Hz. What is the wavelength of the electromagnetic wave that is produced?

30 m

100 m

300 m

1000 m
3. An electromagnetic wave is made up of which of the following oscillating quantities?

- Electrons only
- Electric fields only
- Magnetic fields only
- Electric and magnetic fields

4. The electric field, E, in an electromagnetic wave is oriented in what direction with respect to its associated magnetic field, B?

- E perpendicular to B
- E parallel to B
- E and B at 45° angles
- Depends on the frequency
5. As an electromagnetic wave travels through empty space, its speed can be increased by:

- Increasing its frequency
- Increasing its energy only
- Increasing both its energy and momentum
- None of the above will increase its speed.

6. Every electromagnetic wave is...

- A longitudinal wave.
- A transverse wave.
- A visible light wave.
- An ether wave.
7. The human eye is sensitive to light with wavelength down to 390 nm. What is the frequency of radiation at this wavelength? (1 nm = 10^{-9} m and c = 3.00 \times 10^8 m/s)

1.8 \times 10^8 \text{ Hz}

8.5 \times 10^8 \text{ Hz}

1.1 \times 10^{11} \text{ Hz}

7.7 \times 10^{14} \text{ Hz}

8. The cones in your eye enable you to see color. What statement below is most accurate?

Three cones with overlapping spectral sensitivity

Three cones with non-overlapping spectral sensitivities

Three cones with spectral sensitivities centered on the same wavelength.

Two cones with non-overlapping spectral sensitivities
9. Suppose an eye has two cones, with spectral sensitivities shown below. Which combination of two wavelengths of equal intensity would be perceived as the same color as a single wavelength of 500 nm?

300nm&600nm

300nm&500nm

400nm&600nm

500nm&600nm

10. Which statement is true of color mixing:

- Three colors are required to generate white light.
- Any color can be generated by mixing three primaries.
- Colors outside the color triangle cannot be seen.
- White light can be generated by mixing two colors.
11. A radar pulse returns $3.0 \times 10^{-4}$ seconds after it is sent out, having been reflected by an object. What is the distance between the radar antenna and the object? ($c = 3.00 \times 10^8$ m/s)

- $9.0 \times 10^4$ m
- $4.5 \times 10^4$ m
- $6.0 \times 10^4$ m
- $1.0 \times 10^4$ m
Answers:

1) The force on a particle from an electric field is equal to (Electric field)x(Charge of particle). Since the charges of the particles are equal and opposite, so are the forces.

2) The wiggling charge produces an EM wave of the same frequency. Using wavelength x frequency = propagation speed. Wavelength=(3x10^8 m/s)/(10^6 m)=300 m By the way, 1,000,000 Hz is '1000' on your AM dial.

3) An EM wave has both electric field and magnetic field components, hence its name.

4) The E and B fields in an EM wave are perpendicular to each other, but both still propagate in the same direction.

5) All electromagnetic waves travel at a fixed velocity c (the speed of light) when traveling through empty space.
6) An electromagnetic is a transverse wave. The electric and magnetic fields in the wave are both perpendicular to the direction of propagation. Compare this to a sound wave, where the motion of air molecules is in the same direction as the propagation direction of the sound wave.

7) \[
\text{wavelength} \times \text{frequency} = \text{propagation speed} \\
\text{wavelength} = (3\times10^8\text{m/s})/(3.9\times10^7\text{m}) \\
= 7.7\times10^4\text{ Hz}
\]  

8) Your eye contains three cones, sensitive to three different regions of the visible spectrum, but with substantial overlap in the spectral sensitivities of the cones.

9) 500 nm radiation equally stimulates the red and blue cones. 400 nm and 600 nm also equally stimulate the two cones when they have equal intensity. The intensity would be adjusted to get the stimulation as the 500 nm stimulus.
10) Two complementary colors can be combined to generate white. Only colors within a color triangle can be generated by combining three primaries. Colors outside a color triangle cannot be generated by combining the three primaries, but the eye could still see them if they were generated by some other means.

11) The radar pulse makes one complete round trip, traveling a total length of $2d$. So

$$2d = (3 \times 10^8 \text{ m/s}) \times (3 \times 10^{-4} \text{ s}) = 9 \times 10^4 \text{ m}$$

Then $d = 4.5 \times 10^4 \text{ m}$