Practice Problems Chapter 34

Electromagnetic Waves

Multiple Choice

1. The Earth is 1.49×10^{11} meters from the sun. If the solar radiation at the top of the Earth's atmosphere is 1340 W/m^2, what is the total power output of the sun?

a. 7.10×10^{27} W
b. 2.20×10^{30} W
c. 6.62×10^{26} W
d. 3.74×10^{26} W
e. 2.98×10^{25} W

4. Find the force exerted by reflecting sunlight off a reflecting aluminum sheet in space if the area normal to the sunlight is 10 000 m^2 and the solar intensity is 1350 W/m^2.

a. 0.72 N
b. 0.09 N
c. 9 N
d. 45 N
e. 0.18 N

5. What is the average value of the magnitude of the Poynting vector **S** at 1 meter from a 100-watt lightbulb radiating in all directions?

a. 1 W/m^2
b. 4 W/m^2
c. 2 W/m^2
d. 8 W/m^2
e. 12 W/m^2

10. What is the maximum radiation pressure exerted by sunlight in space (S = 1350 W/m^2) on a highly polished silver surface?

a. 1.4×10^{-2} Pa
b. 0.12 Pa
c. 9.0×10^{-6} Pa
d. 4.5×10^{-5} Pa
e. 2.3×10^{-6} Pa

17. The magnetic field of a plane-polarized electromagnetic wave moving in the z-direction is given by $B = 1.2 \times 10^{-6} \sin\left[2\pi\left(\frac{z}{240} - \frac{t \times 10^7}{8}\right)\right]$ in SI units. What is the wavelength of the EM wave?

a. 120 m
b. 240 m
c. 60 m
d. 100 m
e. 360 m

20. A solar cell has a light-gathering area of 10 cm^2 and produces 0.2 A at 0.8 V (DC) when illuminated with $S = 1000\ W/m^2$ sunlight. What is the efficiency of the solar cell?

a. 16%
b. 7%
c. 23%
d. 4%
e. 32%

21. High frequency alternating current is passed through a solenoid that contains a solid copper core insulated from the coils of the solenoid. Which statement is correct?

a. A copper core remains cool no matter what the frequency of the current in the solenoid is.
b. The copper core remains cool because the induced emf is parallel to the solenoid axis and fluctuates rapidly.
c. The copper core heats up because an emf parallel to the solenoid axis is induced in the core.
d. The copper core heats up because circular currents around its axis are induced in the core.
e. The copper core heats up because the electric field induced in the copper is parallel to the magnetic field produced by the solenoid.

22. In an electromagnetic wave, 1) how are the electric and magnetic field directions related and 2) how is the direction of travel determined from their directions? (**c** is the velocity of the light wave.)

a. $\mathbf{E} \parallel \mathbf{B}$; $\frac{\mathbf{c}}{c} = \frac{\mathbf{E} \times \mathbf{B}}{|\mathbf{E} \times \mathbf{B}|}$.

b. $\mathbf{E} \parallel \mathbf{B}$; $\frac{\mathbf{c}}{c} = \frac{\mathbf{B} \times \mathbf{E}}{|\mathbf{B} \times \mathbf{E}|}$.

c. $\mathbf{E} \perp \mathbf{B}$; $\frac{\mathbf{c}}{c} = \frac{\mathbf{E} \times \mathbf{B}}{|\mathbf{E} \times \mathbf{B}|}$.

d. $\mathbf{E} \perp \mathbf{B}$; $\frac{\mathbf{c}}{c} = \frac{\mathbf{B} \times \mathbf{E}}{|\mathbf{B} \times \mathbf{E}|}$.

e. $\mathbf{E} = \mathbf{B}/\mathrm{c}$; $\frac{\mathbf{c}}{c} = \frac{\mathbf{B} \times \mathbf{E}}{|\mathbf{B} \times \mathbf{E}|}$.

23. The intensity of radiation reaching the earth from the sun is 1350 W/m^2. The earth's radius is 6.4×10^6 m. How big a force does this radiation exert on the earth? (Assume it is all absorbed.)

a. 5.8×10^8 N
b. 1.2×10^9 N
c. 2.3×10^9 N
d. 4.6×10^9 N
e. 1.7×10^{17} N

Open-Ended Problems

31. Near the surface of the planet, the Earth's magnetic field is about 0.5×10^{-4} T. How much energy is stored in 1 m^3 of the atmosphere because of this field?

32. The sun radiates energy at a rate of 3.86×10^{26} W. Its radius is 7.0×10^8 m. If the distance from the Earth to the sun is 1.5×10^{11} m, what is the intensity of solar radiation at the top of the Earth's atmosphere?

33. A possible means of spaceflight is to place a perfectly reflecting aluminized sheet into Earth orbit and use the light from the sun to push this solar sail. If a huge sail of area 6×10^5 m^2 and mass 6000 kg were placed into orbit and turned toward the sun, what would be the force exerted on the sail? (Assume a solar intensity of 1380 W/m^2.)

Chapter 34

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1. d
2. b
3. c
4. b
5. d
6. a
7. a
8. b
9. d
10. c
11. a
12. a
13. c
14. d
15. d
16. c
17. b
18. a
19. b
20. a
21. d
22. c
23. a
24. c
25. a
26. c
27. b
28. e
29. a
30. c
31. 9.9×10^{-4} J
32. 1400 W/m^2
33. 5.52 N