Solutions - PHY3054 - Exam 3 - Fall 1995

1. You are given the magnetic field at a particular instant in time, but you do not know what it was before or after that time. Consequently, you can not determine whether the magnetic field and flux are increasing, decreasing, or staying the same. **Not enough information given.**

2. At $t = 1$ sec. ($x = 1m$) the loop is moving out of the region with a magnetic field into the page. Because the flux into the page is decreasing, the induced current acts to produce a flux into the page (clockwise). The force on the loop is to the right (positive x direction) since the current in the right segment of the loop is down with B into the page. (The top and bottom segments of the loop cancel, and there is no force on the left segment.)

   At $t = 2$ sec. ($x = 0m$) the loop is moving, but there is no change in flux and consequently no induced current. There is no force on the loop since there is no induced current.

   At $t = 3$ sec. ($x = -1m$) the loop is moving into a region with a magnetic field out of the page. Because the flux into the page is increasing, the induced current acts to produce a flux out of the page (counterclockwise). The force on the loop is to the right (positive x direction) since the current for the left segment of the loop is down with B into the page. (The top and bottom segments of the loop cancel, and there is no force on the right segment.)

   $\Rightarrow$ The correct graph for the **current** is **Fig. 1.4**, and the correct graph for the **force** is **Fig. 1.1**.

3. This problem only asks for the magnitude of the induced current. Use Faraday's Law:

$$\begin{aligned} V &= \frac{\text{change in flux}}{\Delta t} = \frac{\text{(change in area)(B)}}{\Delta t} \\ &= \frac{v\Delta t l B}{\Delta t} = vlB = IR \\ \rightarrow I &= \frac{(1m/s)(0.2m)(3T)}{1000\Omega} = \mathbf{0.6mA}. \end{aligned}$$

4. In Fig. 2.1 the flux out of the page is decreasing. According to Lenz's law, the induced current acts to oppose this and produces a flux out of the page (**Counterclockwise**). The magnetic field at the loop in Fig. 2.2 is going into the page. Since the current is increasing, the flux into the page is increasing. Again using Lenz's law, the induced current produces a flux going out of the page (**Counterclockwise**).

5. The area of the loop changes from $(0.1m)^2$ to $(0.17m)^2$. Applying Faraday's Law,

$$V = \frac{((0.17m)^2) - (0.1m)^2)(1T)}{1s} = I(1\Omega) \Rightarrow \mathbf{I = 19mA}$$

6. **The speed of light is at most the speed of light in a vacuum.** In a medium like glass or water, the speed of light can be slower than the speed of light in a vacuum because $v = c/n$. Within a given media, changing the frequency or wavelength does not necessarily change the speed of the light.

7. The net power, which is measured in Watts, remains the same for any sphere centered about the sun: $\mathbf{P = 1 \times 10^{26}}$ **Watts**. The intensity, S=Power/Area, goes down as one goes further away because the Area, $4\pi R^2$, increases.

8. The radiation pressure for an absorbing surface is

$$\begin{aligned}\frac{\text{Force}}{\text{Area}} &= \frac{S}{c} \\ \Rightarrow F &= \frac{(1.5 \times 10^3 W/m^2)(10^4 m^2)}{3 \times 10^8 m/s} = \mathbf{0.05N}.\end{aligned}$$

9. Put your name, social security number, and test number correctly on the bubble sheet and the exam printout.

10. No light will emerge from the final filter if the second filter is either perpendicular to the first polarizer or to the second polarizer. Since the first polarizer is at 0^o and the second polarizer is at 45^0, the correct answer is **90 degrees** and **135 degrees**.

11. The first polarizer reduces the intensity by half because the incoming light is unpolarized. Each of the remaining 5 filters reduces the intensity by $\cos^2(30) = 0.75$.

$$I = \frac{1}{2}\left(\cos^2(30)\right)^5 = 0.12\, I \approx \mathbf{0.1\, I}$$

12. The angle of incidence is $90 - X$. The angle of the transmitted ray is $90 - 75 = 15$. For both of these it is important to realize that the angles are measured from the normal to the surface.

$$\begin{aligned}1\sin(90 - X) &= 1.5\sin(15) \\ 90 - X &= 22.84 \\ \mathbf{X} &\approx \mathbf{67}\end{aligned}$$

13. In order to have total internal reflection one must be going from a media with a higher index of refraction to a media with a lower index of refraction. The critical angle for total internal reflection here is $\sin^{-1}(1.0/1.4) = 45.6^o$. For angles larger than this, there is total internal reflection. $\Rightarrow$ Only **Fig. 5.3** is correct.

14. An object outside of the focal length for a concave mirror will create a **real** and **inverted** image. This can be checked by either drawing a ray diagram or substituting in numbers and finding the $s' > 0$ and $m < 0$.

15. Both Figs. 6.1 and 6.2 are correct. **Fig. 6.3** is not correct for a diverging lens. It would be correct for a converging lens.

16. **Fig. 7.1** is incorrect because a ray going towards the center should come back upon itself. **Fig. 7.3** is incorrect because a ray going towards the focal point should come out horizontally. Fig. 7.2 is correct.

17. For the first (left) lens, $s = 1m$ and $f = 0.3m \rightarrow s' = 0.43m$. Since the lenses are separated by 1m, for the second (right) lens, $s = 0.57m$ and $f = 0.3m \rightarrow s' \approx \mathbf{0.6m}$.

18. Since the image is virtual and $0.5m$ from the lens, $s' = -0.5m$. Since the lens is converging, $f = 2m$.
$$\frac{1}{s} + \frac{1}{-0.5m} = \frac{1}{2} \rightarrow s' = \mathbf{0.4m}$$

19. The magnification is $m = -s'/s = -1/3$, which implies that $s' = s/3$. The mirror is concave so that $f = +R/2 = 0.5m$.
$$\frac{1}{s} + \frac{1}{s/3} = \frac{4}{s} = \frac{1}{0.5m} \rightarrow \mathbf{s = 2m}$$

20. This is a problem involving refraction at a spherical surface. The light is going from the fish to the person so $n = 1.33$ and $n' = 1$. The distance of the fish to the surface of the fish bowl is $s = 2m$. Finally, the radius of the fish bowl is $R = -2m$ because the center is not on the side of the outgoing light.
$$\frac{n}{s} + \frac{n'}{s'} = \frac{n' - n}{R} \Rightarrow s' = -2.0m$$
Thus, the fish appears to be **2.0 m** inside the fish bowl.