

## PHYSICS 112 - REVIEW FOR EXAM 3

**MAGNETIC FLUX:** The magnetic flux through a plane circuit is  $\Phi = BA \cos \theta$ , where  $\theta$  is the angle between  $\vec{B}$  and the normal ( $\equiv$  perpendicular) to the plane of the circuit. Units: T-m<sup>2</sup>.

### MAGNETIC INDUCTION

The current induced in plane loop is proportional to the rate of change of the magnetic flux through the loop. If the loop has electrical resistance  $R$ , the current is given by Faraday's law:  $I = \frac{\Delta\Phi/\Delta t}{R}$ .

### LENZ' LAW

The direction of the induced current in a loop is such as to oppose the change in flux that produced it. Thus if the flux is increasing/decreasing in magnitude, the induced current must produce a magnetic field in the opposite/same direction as the external magnetic field.

### ELECTROMAGNETIC WAVES

A plane electromagnetic waves has electric field  $\vec{E}$  and magnetic field  $\vec{B}$  that are perpendicular to each other and always in phase (zero at same time, maxima and minima at the same time) and always both perpendicular to the direction of propagation  $\vec{c}$ . Use right hand rule to determine directions:  $\vec{B}$ ,  $\vec{c}$ , and  $\vec{E}$  along thumb, forefinger, and middle finger.

Speed of e.m. waves is  $c = 3 \times 10^8$  m/s in a vacuum and  $c/n$  in a material with index of refraction  $n$ . Typical values:  $n = 1$  for a vacuum,  $\approx 1$  for air, 1.33 for water, and about 1.5 for most glasses.

The frequency  $f$  and wavelength  $\lambda$  of an e.m. wave are related to the speed by  $c = f\lambda$  (or  $c/n = f\lambda$  in a material other than the vacuum). Visible light has wavelengths in the range of 400 nm (violet light) to 700 nm (red light).

### GEOMETRICAL OPTICS

When an e.m. wave is incident on an interface between materials of indexes of refraction  $n_1$  (the material in which the incident ray is traveling) and  $n_2$ , both reflection and refraction may occur. Let the incident ray make an angle  $\theta_1$  with the normal to the interface at the point where the incident ray strikes the interface, and let  $\theta_2$  be the angle the refracted ray makes with the normal. The reflected and refracted rays lie in the same plane as the incident ray and the normal, on the other side of the normal from the incident ray. The angle made by the reflected ray with normal is also  $\theta_1$ , while  $\theta_2$  is given by Snell's law:  $n_1 \sin \theta_1 = n_2 \sin \theta_2$ .

Equations for mirrors and lenses:  $1/o + 1/i = 1/f$  and  $m = -i/o$ , where  $o$  is the object distance and  $i$  is the image distance and  $f$  is the focal length. The image is real/virtual according to whether  $i$  is positive/negative; erect/inverted according to whether  $m$  is positive/negative. The magnitude of  $m$  gives the linear magnification (length of image compared to length of object).

For a spherical mirror of radius of curvature  $R$ , the focal length  $f = R/2$  for a concave mirror (light incident from side with radius of curvature) and  $f = -R/2$  for a convex mirror.

For a convergent lens (thicker in the middle),  $f > 0$ . For a real object ( $o > 0$ ),  $i$  can be positive or negative, depending on the location of the object relative to the focal point.

For a divergent lens (thinner in the middle),  $f < 0$ . For a real object ( $o > 0$ ),  $i$  must be negative, giving a virtual, erect, smaller image.