1. A concave mirror is designed so that a person 20 cm in front of it sees an upright image, 1.5 times as large as his/her own face. What is the radius of curvature of the mirror?

Given $M = +1.5$, $o = 20$ (use cm units). Since $M = -i/o$, $i = -M\,o = -30$ cm.
$1/o + 1/i = 2/R$; $1/20 + 1/(-30) = 0.01667$, so $R = 120$ cm.

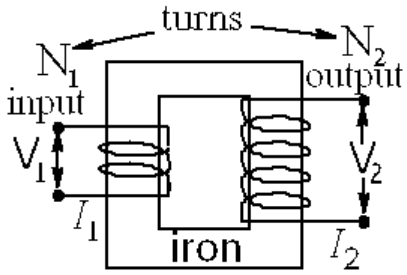
2. In one of your labs, you measured the resonant frequency of a series RLC circuit, and compared to the value expected from the component values. If the resistor has a value of 50 ohms, the capacitor a value of $1.00\text{x}10^{-7}$ F, and the inductor 0.0100 H, each with an uncertainty of 5%, what is the relative uncertainty of the predicted frequency?

$\omega = 1/\sqrt{LC} = L^{-1/2}C^{-1/2}$, so

$$\frac{\Delta f}{f} = \frac{\Delta \omega}{\omega} = \sqrt{\left(\tfrac{1}{2}\frac{\Delta L}{L}\right)^2 + \left(\tfrac{1}{2}\frac{\Delta C}{C}\right)^2} = \sqrt{\left(\tfrac{1}{2}\times.05\right)^2 + \left(\tfrac{1}{2}\times.05\right)^2} = 0.03535 = 3.5\%$$

3. Assume an ideal transformer with N_1 turns for the input (primary) and N_2 turns for the output (secondary); N_2 is greater than N_1. V_1, V_2, I_1, and I_2 are the rms alternating voltages and currents at the input and output windings. Which of the following is correct?

The power in the primary circuit is equal to the power in the secondary circuit.



4. If the components of the series RLC circuit shown above have the following values: R = 100 Ω, C = 1.8 x 10^{-8} F, L = 0.025 Hy, and the signal generator is set to a frequency of 4000 Hz and an rms voltage of 1.00 V, what is the rms voltage measured across the resistor?

We are given the driving voltage, but to find the voltage across the resistor, we need the current, which follows from the impedance. Since given and requested voltages are rms, we don't need to convert to peak.

$X = \sqrt{R^2 + (X_L - X_C)^2}$

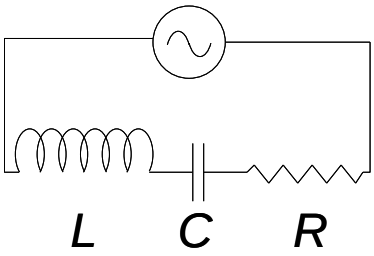
$X_L = 2\pi fL = 2\pi \times 4000 \times 0.025 = 628\Omega$

$X_C = 1/(2\pi fC) = 1/(2\pi \times 4000 \times 1.8 \times 10^{-8}) = 2211\Omega$

so $X = \sqrt{100^2 + (628 - 2211)^2} = 1586\Omega$

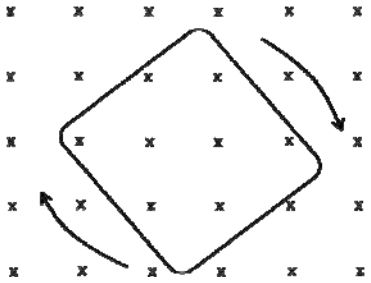
$I = V/X = 1.00/1586 = 0.00063$ Amp

$V_R = IR = 0.0063$ Volt

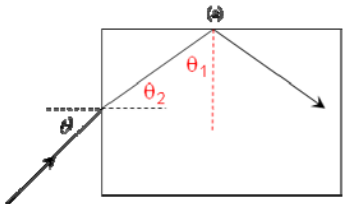


5. A beam of light which has a wavelength of 550 nm in air enters a piece of glass where the index of refraction is 1.45. What is the wavelength of the light in the glass?
$\lambda' = \lambda/n = 550/1.45 = 379$ nm

6. A square loop of wire is rotated clockwise, in a plane that is perpendicular to a uniform magnetic field directed into the page, as shown. Which direction does the induced current flow in the loop?
There is no induced current because the magnetic flux through the loop is not changing.



7. Here is a rectangular block of plastic, with an index of refraction of 1.25. A ray of light enters from the left at an angle θ from the normal as shown, is refracted into the glass, but no light is observed to come out of the glass at point (a). What can you conclude about the angle θ?
Total internal reflection at (a) means sin $\theta_1 > 1/n$,
so $\theta_1 > 53.13°$. That means that $\theta_2 < (90\text{-}53.13) = 36.87°$.
By Snell's law, sin $\theta = n \sin \theta_2 < 0.75$, so $\theta < 48.6°$



8. If there is no current flowing through a capacitor, which is correct?
$I = C(\Delta V/\Delta t)$. If $I = 0$, $\Delta V = 0$; the voltage is not changing, so it could have any constant value.

9. An object 0.3 cm in size is 15 cm to the left of a converging lens which has a 25 cm focal length. The image is:
$o = 15$. $f = 25$. $1/i = 1/f - 1/o = 1/25 - 1/15 = -0.0267$, so $i = -37.5$ cm. The negative sign means the image is virtual, therefore on the left side of the lens (the same side as the real image). $M = -i/o$ is positive, so the image is upright.

10. A person underwater in a swimming pool looks up and sees the Sun at an apparent angle of 30° away from the vertical. The index of refraction of water is 1.333. What is the actual position of the sun away from the vertical (to the nearest degree)?
The normal to the surface is vertical, so the angle of refraction in the water is 30°. By Snell's law, $\sin \theta_{Air} = n \sin \theta_{Water} = 1.333 \times \sin 30° = 0.6665$. $\sin^{-1} 0.6665 = 41.8°$, which is the angle from the vertical.

11. The tuning circuit of a radio receiver has an RLC circuit with $L = 3\text{x}10^{-8}$ Henry. What value of C will be resonant with 90.1 MegaHertz?

$f = \frac{1}{2\pi\sqrt{LC}}$, so $C = \frac{1}{(2\pi f)^2 L} = 1.04\times10^{-10}$ F

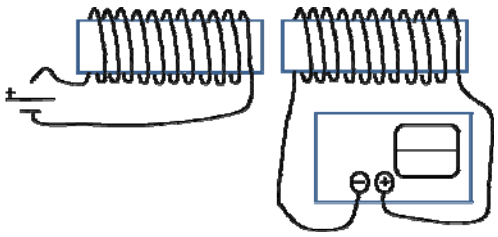
12. To make an AC generator with peak voltage (EMF) 100 V, from a coil of area 0.001 m^2, turning in a magnetic field of 0.03 Tesla at a rate of 400 revolutions per second, how many turns are required in the loop? Pick the closest answer.

$V_{peak} = N\,A\,B\,2\pi\,f$, so $N = V_{pk} / (2\pi\,f\,A\,B) = 100 / (2\pi\ 400\ .001\ .03) = 1326$.

13. The current through a given inductor increases from zero to 2 mA in 0.2 seconds, while an induced voltage of .030 V appears across the inductor. What is the inductance?

$V = L\ (\Delta I / \Delta t)$, so $L = 0.030$ x 0.2 / $2\text{x}10^{-3}$ = 3 Henry

14. The two coils shown are wound in the same direction. When the loose wire from the coil is connected to the + terminal of the battery as shown, what happens to the oscilloscope trace?



When the wire is connected, current starts to flow in the left coil, from left to right..
According to the right hand rule, it produces a magnetic field that points to the right, and is increasing. This induces an EMF in the right coil, which would oppose the changing field, i.e., in the direction to produce a field pointing to the left. That makes the (-) terminal of the oscilloscope more positive, so **the trace jumps down**. Some time later, the field is no longer changing, so the oscilloscope trace **returns to its original position**.

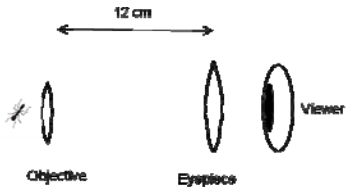
15. Unpolarized light passes through three polarizers in succession. The first one is oriented with its polarization axis vertical; the second has its axis inclined 30° from the vertical, and the third is horizontal. What fraction of the original intensity is passed through all three polarizers?

Half of the unpolarized light is blocked in the first polarizer, from whence it emerges polarized. By Malus's law, the fraction transmitted by the second polarizer is $\cos^2 30° = ¾$. That light is now polarized 30° from the vertical, so the 3rd (horizontal) polarizer passes $\cos^2 60° = ¼$. Overall, what is passed is ½ x ¾ x ¼ = 3/32 = 9.38%

16. Light of wavelength 570 nm is incident on a slit which is 0.3 mm wide. Viewed on a screen 2.0 meters away, what is the separation between the central and the next bright band (spot)?

Single slit diffraction. $m\lambda = b \sin\theta = bx/D$. The central spot corresponds to $m = 0$, and the next spot to m=1.5. So $x = 1.5\ \lambda\ D / b$ = 1.5 x $570\text{x}10^{-9}$ x 2.0 / $0.3\text{x}10^{-3}$ = 5.7 mm

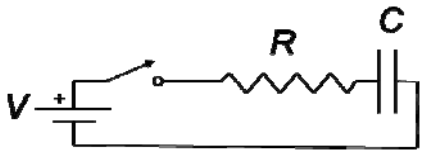
17. This sketch (not to scale) shows a microscope in which the objective lens has a focal length of 0.3 cm, the eyepiece has a focal length of 2 cm, the two lenses are 12 cm apart, and the eye sees a virtual image at an apparent distance of 25 cm from the eyepiece. Where is the intermediate image?



Between the two lenses. The intermediate image is the object viewed by the eyepiece, which according to the data given is 1.85 cm in front (to the left, in this sketch) of they eyepiece.

18. In the circuit shown, the switch is initially open and there is no current flowing. A very long time after the switch is closed, the current is equal to:

Zero. Long after the switch is closed, the capacitor is charged to the battery voltage *V*, so there is no voltage across the resistor, and therefore no current through it.



19. A 75 Watt light bulb is plugged into a supply of 120 Volts rms. Which of the following is correct?

RMS current is 75 Watt / 120 V = 0.625 A, so peak current is $2^{1/2}$ x 0.625 = 0.88 Amp. Voltage and current are in phase because it is a resistive load, not capacitive or inductive. Peak voltage is 120 x $2^{1/2}$ = 170 V.

20. A simple magnifier consists of a converging lens of focal length 6.25 cm; it is used to produce an image 25 cm in front of the lens (side opposite the viewer). What is the magnification (including sign)?

Image on the side opposite the viewer means that the image is virtual, so $i = -25$ cm. $1/i + 1/o = 1/f$, so $o = 5.00$ cm. Then $m = -i/o = -(-25)/5 = 5$.