Test 2

Remember:
Show all your work for full credit. Minimum of 3 steps:
• What equation are you plugging into?
• What numbers are you substituting?
• What is your final answer?
Ask if anything seems unclear.

Formulae and Constants:

- \( e = 1.60 \times 10^{-19} \) Coulombs
- \( 1 \text{ eV} = 1.60 \times 10^{-19} \text{ J} \)
- \( E = h f \)
- \( h = \text{Planck’s const} = 6.63 \times 10^{-34} \text{ J}\cdot\text{s} \)
- \( c = \lambda f \)
- \( c = \text{“speed of light”} = 1 / \sqrt{\varepsilon_0 \mu_0} = 3 \times 10^8 \text{ m/s} \)
- \( E = \frac{hc}{\lambda} \)
- \( hc = 1240 \text{ eV}\cdot\text{nm} \)

Reflection/refraction
\( n = \frac{c}{v} \)
\( \lambda_n = \frac{\lambda}{n} \)
Snell’s Law: \( n_a \sin \theta_a = n_b \sin \theta_b \) where a is the incident medium and b the refracted one.

Reflections from curved surfaces = mirrors:
Lenses:
Mirror Equations
\( - \frac{1}{u} + \frac{1}{v} = \frac{1}{f} \)
\( \frac{1}{u} + \frac{1}{v} = \frac{2}{r} = \frac{1}{f} \)
magnification
\( m = \frac{h_i}{h_o} = \frac{v}{u} \)

Lens Maker’s Equation:
\( \frac{1}{f} = \left[ \frac{(n_2 - n_1)}{n_1} \right] \left[ \frac{1}{r_1} - \frac{1}{r_2} \right] \)

3 standard rays for ray diagrams:
(1) in thru focus, out parallel to axis; (2) in parallel, out thru focus; (3)in thru center, undeviated

Textbook sign conventions:
• if the object/image is to the left of the vertex (where lens/mirror crosses axis), its distance u/v is negative
• radii of curvature follow the same rule as above, so diverging mirrors have positive \( f \) = focal lengths, but diverging lenses have negative focal lengths

For step-index fibers
Numerical Aperture = N.A. = \( n_o \sin \theta_m = \sqrt{n_1^2 - n_2^2} \)

- Skip distance \( L_s = n_2 \frac{d}{\sqrt{n_1^2 - n_2^2}} \)
- \# of modes = \( \left( \frac{1}{2} \right) \left[ \pi d (\text{N.A.}) / \lambda \right]^2 \)
in order to be single-mode, a fiber diameter \( d \) must be:
\( d < 2.4 \lambda / \pi (\text{N.A.}) \)

For fibers in general:
Loss of power in dB = \( \alpha L = 10 \log_{10} \left( \frac{P_1}{P_2} \right) \)
where \( \alpha \) is the attenuation coefficient

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