SUPERQUIZ Practice Test Instructions: Display principal equation below problem, best answer in the blank provided.

_____ 1. A diffraction grating has 2000 lines per centimeter. Monochromatic light is found to have a second maximum 4 cm up from the central maximum on a screen 3 meters away. Find the wavelength of the light in nanometers. (A) 667 (B) 333 (C) 427 (D) 512 (E) none of these

$$d \sin\theta = m\lambda$$
$$tan\theta \approx \theta = \frac{D}{L}$$

_____ 2. What size aperture would be necessary, approximately, to resolve continents 4000 km across on a world in the Andromeda Galaxy, two million light years away? There are 9.46 trillion kilometers in a light year. Pick best answer, in km. (A) 1 (B) 10 (C) 100 (D) 1000 (E) 10,000

$$a\theta = \lambda$$
$$\theta = \frac{D}{L}$$

_____ 3. Oil with n=1.2 forms a thin layer on water, n=1.33. Light with wavelength 600 nm is found missing in the reflected light. Find the minimum possible thickness of the oil layer, in nm. (A) 150 (B) 300 (C) 450 (D) 600 (E) none of these

The light is missing because of destructive interference. Reflections off the top and bottom of the oil layer both undergo phase inversion, so the usual definitions apply. For destructive interference,

$$2t = \left(m + \frac{1}{2}\right)\frac{\lambda}{n}$$

_____ 4. Light of wavelength 400 nm irradiates metal in a photoelectric experiment. A stopping voltage of 1.2 volts is sufficient to cause current in the apparatus to cease. Find the work function of the metal, in eV. (A) 1.2 (B) 1.5 (C) 1.9 (D) 2.4 (E) none of these

$$hf = h\frac{c}{\lambda} = W + eV$$

_____ 5. What speed electron will have the same wavelength as a 2 eV photon? Pick closest in m/s. (A) 100 (B) 400 (C) 600 (D) 1000 (E) 2000

For the material particle,

$$\lambda = \frac{h}{p} = \frac{h}{mv}$$

while for the photon,

$$E = hf = h\frac{c}{\lambda}$$

_____ 6. Suppose a particle is trapped in a one-dimensional box, $0 < x < L$. If the wavefunction is given by

$$\psi = \sqrt{\frac{2}{L}} \sin\left(\frac{3\pi x}{L}\right)$$

find the probability that the particle will be found in the interval $0 < x < L/3$. Pick closest. (A) 0.1 (B) 0.2 (C) 0.3 (D) 0.4 (E) 0.5

7. Suppose a star is brightest in an energy band centered on 620 nm. What's the temperature of the star?

$$\lambda_{max} = \frac{0.0029}{T}$$

8. A piece of tissue paper 1×10^{-6} m is placed between two slides at one end. Light of 450 nm is shone from above. How many dark lines per centimeter are observed?

9. Incoherent light is incident on a polarizer. At what angle should the polarization axis of a second polarizer be arranged with respect to the first so that the transmitted light is reduced by 80%?

Going through the first polarizer, get

$$I = \frac{I_0}{2}$$

For the second,

$$\frac{I_0}{2}\cos^2\theta = 0.2I_0$$

10. Suppose a particle is trapped in a box one femtometer wide. Find the minimum energy of the particle, according to the uncertainty principle.

$$\Delta p \Delta x > \frac{\hbar}{2}$$

$$\Delta p = \sqrt{< p^2 > - < p >^2} = \sqrt{< p^2 >}$$

$$E > \frac{< p^2 >}{2m}$$

Plug one femtometer into the first inequality, sub second into first, then into third.

11. The average electric field energy density of laser light impinging on a 10,000 kg perfectly reflecting solar sail with area 1 square kilometer is 20,000 N/C. Find the acceleration of the sail.

$$S_{av} = \frac{1}{2}\frac{E_{max}B_{max}}{\mu_0}$$

$$E = Bc$$

$$F = ma = \frac{2IA}{c}$$

12. Find sine waves describing an electromagnetic wave that has magnetic field maximum of 4×10^{-5} T in the z-direction at y=0, t=0, and which travels in the positive y-direction with wavelength 200 m.

$$\vec{E} = E_{max} \sin(ky - \omega t + \delta)\,\hat{x}$$

$$k = \frac{2\pi}{\lambda}$$

$$c = f\lambda$$

$$\omega = 2\pi f$$

$$E = Bc \quad \delta = \frac{\pi}{2}$$