DO NOT TURN OVER THIS PAGE UNTIL INSTRUCTED TO DO SO

PUT AWAY ALL BOOKS, NOTES, PHONES, COMPUTERS AND STUDY AIDS

INSTRUCTIONS:

1. Print your full name below

LAST NAME          FIRST NAME          MIDDLE INITIAL

2. Write your code number below

ENTER YOUR CODE NUMBER INTO THE “EXAM NUMBER” PART OF YOUR SCANTRON. If you do not remember your code number, or have some doubt about what it is, come up and see Forrest at the front of the room.

3. ENTER THE TEST VERSION IN THE “TEST FORM” BOX ON YOUR SCANTRON.

4. Flip over this page when instructed to begin the exam.

5. There are 10 problems ranging in difficulty.

6. All answers should be marked on the scantron form WITH PENCIL; no work needs to be shown.

8. An equation sheet is provided on the last page of the exam for reference. You may detach the equation sheet from the quiz.

9. Answer all questions.

10. When you have completed your quiz, turn in your scantron AND this copy of the quiz.

GOOD LUCK!
1. The reason there are two slits, rather than one, in Young’s Double Slit Experiment is:
   a. to increase the intensity.
   b. to create a path length difference for the light.
   c. one slit is for frequency, the other for wavelength.
   d. two slits in parallel offer less resistance.
   e. one slit is for $E$ fields, the other is for $B$ fields.

2. In an experiment to measure the wavelength of light using a double slit, it is found that the fringes are too close together to easily count them. To spread out the fringe pattern, one could:
   a. decrease the slit separation, $d$.
   b. increase the slit separation, $d$.
   c. increase the width of each slit, $w$.
   d. decrease the width of each slit, $w$.
   e. decrease the screen-to-slit distance, $L$.

3. According to Heisenberg’s uncertainty principle, the more accurately we know about a subatomic particle’s momentum, the less we know about its precise:
   a. kinetic energy.
   b. mass.
   c. speed.
   d. location.
   e. energy.

4. Young’s Double Slit Experiment is performed with 589 nm light and a distance of 2.00 m between the slits and the screen. The fifth interference minimum is observed 7.50 mm from the central maximum. Determine the spacing of the slits.
   a. 1.54 mm.
   b. 0.864 mm.
   c. 0.785 mm.
   d. 0.628 mm.
   e. 0.707 mm.
5. An electron and a proton both moving at nonrelativistic speeds have the same de Broglie wavelength. Which of the following are also the same for the two particles?
   a. The speed is the same for both particles.
   b. The kinetic energy is the same for both particles.
   c. The momentum is the same for both particles.
   d. The frequency is the same for both particles.
   e. All of the above statements are correct.

6. Electromagnetic radiation with a wavelength of $5.70 \times 10^{-12}$ m is incident on stationary electrons. Radiation that has a wavelength of $6.57 \times 10^{-12}$ m is detected at a scattering angle of:
   a. $0^\circ$.
   b. $120^\circ$.
   c. $40^\circ$.
   d. $50^\circ$.
   e. $60^\circ$.

7. Two stars emitting light of wavelength 500 nm are very closely spaced when viewed from earth. When looking at the night sky, the pupil of your eye dilates to a diameter of 9 mm. By Raleigh’s criterion, what is the minimum angular separation required between the two stars for you to resolve them separately, rather than as a single star?
   a. $4.56 \times 10^{-4}$ rad.
   b. $5.56 \times 10^{-5}$ rad.
   c. $6.78 \times 10^{-5}$ rad.
   d. $3.50 \times 10^{-6}$ rad.
   e. $7.42 \times 10^{-6}$ rad.

8. A sodium surface is illuminated with light of wavelength 300 nm. The work function for sodium metal is 2.46 eV. Find the maximum kinetic energy of the ejected photoelectrons.
   a. 4.13 eV.
   b. 2.46 eV.
   c. 1.67 eV.
   d. 6.59 eV.
   e. 0.54 eV.
9. Helium-neon laser light ($\lambda = 635$ nm) is sent through a 0.650 mm wide single slit. What is the width of the central maximum on a screen 7.50 m from the slit?

- a. 14.7 mm.
- b. 9.77 mm.
- c. 4.22 mm.
- d. 2.61 mm.
- e. 7.33 mm.

10. An oil film ($n_{oil} = 1.30$) floating on an experimental unknown fluid ($n_{unknown} = 1.25$) is illuminated by white light at normal incidence. The film is 125 nm thick. Find the longest wavelength of light in the visible spectrum that is most strongly reflected.

- a. 217 nm.
- b. 433 nm.
- c. 325 nm.
- d. 650 nm.
- e. 541 nm.
Equations and constants:

\[
\begin{align*}
\begin{aligned}
x &= r \cos \theta; \\
y &= r \sin \theta;
\end{aligned} & \quad \begin{aligned}
\theta &= \tan^{-1} \left( \frac{y}{x} \right); \\
r &= \sqrt{x^2 + y^2}; \\
v &= v_o + at; \\
\Delta x &= \frac{1}{2} (v_o + v)t; \\
v' &= v_o^2 + 2a \Delta x; \\
\Delta \theta &= \sin \theta = \frac{n_o}{n_1}; \\
\sin \theta &= \frac{n_a}{n_v}; \\
\sin \theta &= \frac{n_v}{n_o}.
\end{aligned}
\end{align*}
\]

\[
\begin{align*}
\begin{aligned}
a &= \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}; \\
v &= \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}; \\
a_{avg} &= \frac{\Delta v}{\Delta t}; \\
v_{avg} &= \frac{\Delta x}{\Delta t}; \\
\sum \vec{F} &= 0; \\
\sum \vec{F} &= m \vec{a}; \\
\vec{F}_{F_{on2}} &= -k_{spring}(\Delta \vec{x});
\end{aligned}
\end{align*}
\]

\[
\begin{align*}
U_{grav} &= mgh; \\
K &= \frac{1}{2} mv^2 - \frac{D^2}{2m}; \\
U_{spring} &= \frac{1}{2} k_{spring}(\Delta x)^2; \\
W &= \vec{F} \cdot \Delta \vec{x} \cos \theta;
\end{align*}
\]

\[
\begin{align*}
E_{mech} &= K + U_{grav} + U_{spring}; \\
v_{wave} &= \frac{\lambda f}{T}; \\
v_{sound\ air\ at\ 20^\circ C} &= 343 m/s; \\
\varepsilon_o &= 8.85 \times 10^{-12} \frac{C^2}{N \cdot m^2}; \\
\mu_o &= 4\pi \times 10^{-7} \frac{T \cdot m}{A}; \\
c &= \frac{1}{\sqrt{\mu_o \varepsilon_o}} = 3.00 \times 10^8 m/s; \\
n &= \frac{c}{v}; \\
\theta_{incidence} &= \theta_{reflection}; \\
n_1 \sin \theta_1 &= n_2 \sin \theta_2; \\
\sin \theta_1 &= \frac{n_2}{n_1}; \\
n_{air} &= n_{vacuum} = 1.00; \\
n_{water} &= 1.333; \\
\delta &= d \sin \theta_{bright} = m \lambda \ (m = 0, \pm 1, \pm 2, \ldots); \\
\delta &= d \sin \theta_{dark} = \left( m + \frac{1}{2} \right) \lambda \ (m = 0, \pm 1, \pm 2, \ldots); \\
\text{For small } \theta, \\
\sin \theta &= \theta = \tan \theta = \frac{y}{L};
\end{align*}
\]

\[
\begin{align*}
\gamma_{bright} &= L \tan \theta_{bright}; \\
\gamma_{dark} &= L \tan \theta_{dark}; \\
I_{avg} &= I_{max} \cos^2 \left( \frac{\pi d \sin \theta}{\lambda} \right);
\end{align*}
\]

\[
\begin{align*}
\text{const.} & \quad 2nt = (m + \frac{1}{2}) \lambda \quad \text{1 phase reversal} \quad 2nt = m \lambda \quad \text{dest.} \\
0,2 \text{ phase reversals} & \quad 2nt = m \lambda
\end{align*}
\]

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\begin{align*}
\sin \theta_{dark} &= m \frac{\lambda}{a}; \\
\theta_{min} &= 1.22 \frac{\lambda}{D}; \\
\lambda_{max} &= 0.2898 \times 10^{-2} m \cdot K; \\
E_n &= nhf; \\
KE_{max} &= e\Delta V_s;
\end{align*}
\]

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\begin{align*}
KE_{max} &= hf - \phi; \\
\lambda_c &= \frac{hc}{\phi}; \\
hc &= 1.240 \text{ eV} \cdot \text{nm}; \\
\Delta \lambda_{Compton} &= \lambda' - \lambda_o = \frac{h}{m \cdot c} (1 - \cos \theta);
\end{align*}
\]

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\begin{align*}
\frac{\hbar}{m \cdot c} &= 0.00243 \text{ nm}; \\
p_{\text{photon}} &= \frac{E}{c} = \frac{h}{\lambda}; \\
\lambda_{\text{de Broglie}} &= \frac{h}{p} = \frac{h}{mv}; \\
h &= \frac{h}{2\pi}; \\
\Delta \lambda \Delta p &\geq \frac{\hbar}{2}; \\
\Delta E \Delta t &\geq \frac{\hbar}{2};
\end{align*}
\]

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\begin{align*}
A_{\text{circle}} &= \pi r^2; \\
A_{\text{sphere}} &= 4\pi r^2; \\
g &= 9.80 \text{ m/s}^2; \\
h &= 6.626 \times 10^{-34} \text{ J} \cdot \text{s}; \\
E &= 1.602 \times 10^{-19} \text{ J}; \\
m_e &= 9.11 \times 10^{-31} \text{ kg}; \\
m_p &= 1.673 \times 10^{-27} \text{ kg}; \\
m_n &= 1.675 \times 10^{-27} \text{ kg}; \\
2.54 \text{ cm} &= 1 \text{ in}; \\
1 \text{ nm} &= 1 \times 10^{-9} \text{ m}; \\
5,280 \text{ ft} &= 1 \text{ mi}; \\
0.3048 \text{ m} &= 1 \text{ ft}.
\end{align*}
\]