Post on Monday 4/29

April 25, 2002

Physics 104 Exam 3

Name DEL ID #

Section # TA Name

Fill in your name, student ID # (not your social security #), and section # on the scantron sheet. Fill in the letters given for the first 5 questions on the scantron sheet. These letters determine which version of the test you took and are IMPORTANT to get right.

1. B

2. D

3. C

4. A

5. E

6. A parabolic mirror can be used instead of a spherical mirror to reduce the occurrence of which of the following effects?

   a. chromatic aberration
   b. light scattering
   c. astigmatism
   [✓ d.] spherical aberration
   e. mirages

7. If a man wishes to use a plane mirror on a wall to view both his head and his feet as he stands in front of the mirror, the required length of the mirror:

   a. depends on the distance the man stands from the mirror.
   b. depends on both the height of the man and the distance from the man to the mirror.
   c. is equal to one third the height of the man.
   d. is equal to the height of the man.
   [✓ e.] is equal to one half the height of the man.

8. An object is 15 cm from the surface of a spherical Christmas tree ornament that is 5 cm in diameter. What is the magnification of the image?

   [✓ a.] +0.077
   b. +0.154
   c. -0.091
   d. -0.055
   e. +0.033

$f = -1.25 \quad (\frac{1}{2}R;\ R = \frac{1}{2}D = 2.5)$

$\frac{1}{p}+\frac{1}{q} = \frac{1}{15}+\frac{1}{q} = \frac{1}{-1.25} = -0.8$

$\frac{1}{q} = -0.8 - \frac{1}{15} = -.883$ VIRTUAL IMAGE

$q = -1.13 \quad M = -q/p = 1.13/15 = .075$

9. If atmospheric refraction did not occur, how would the apparent time of sunrise and sunset be changed?

REFRACTIVE BEND MAKES

SUNRISE EARLIER

- [✓ a.] sunrise would be later and sunset earlier
- b. sunrise would be earlier and sunset later
- c. neither would be changed
- d. both would be later
- e. both would be earlier

10. Polarization of light can be achieved using materials like Polaroid by which of the following processes?

- [✓ a.] selective absorption
- b. scattering
- c. inversion
- d. reflection
- e. double refraction

11. Polarization of light can be achieved using birefringent materials by which of the following processes?

- a. selective absorption
- b. inversion
- [✓ c.] double refraction
- d. reflection
- e. scattering

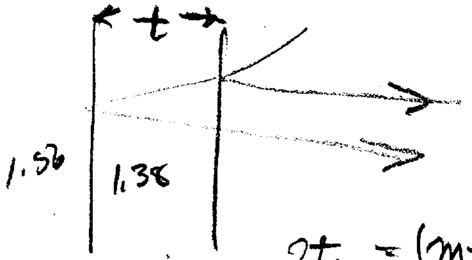
12. When light passes from a material with a high index of refraction into material with a low index of refraction:

- a. some light is reflected with a 180° change of phase.
- [✓ b.] some light is reflected without a change of phase.
- c. none of the light is reflected.
- d. the light that is not reflected has a 108° change of phase.
- e. all of the light is reflected with a 180° change of phase.

13. A thin film of magnesium fluoride (n = 1.38) is used to coat a camera lens (n = 1.56). Which of the following thicknesses of coating will not allow any strong reflections in the visible spectrum (λ = 390 nm to λ = 700 nm)?

- [✓ a.] 1×10^{-5} cm
- b. 3×10^{-5} cm
- c. 5×10^{-5} cm
- d. 1×10^{-4} cm
- e. 3×10^{-4} cm

USE λ = AVERAGE OF 390, 700 $\cong$ 550



BOTH HAVE PHASE CHANGE, SO

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

FOR DESTRUCTIVE

IF $m = 0$

$2t = \frac{1}{2}\lambda/1.38$

$t = \lambda/4 \times 1.38$

$= 550/552$

$\boxed{t \cong 100 \text{ nm}}$

14. How far above the horizon is the moon when its image reflected in calm water is completely polarized? ($n_{\text{water}} = 1.333$)

- a. 22.2°
- b. 28.4°
- c. 16.6°
- d. 7.7°
- [✓ e.] 36.9°

$$\text{TAN } \theta_p = \frac{1}{n} = 1/1{,}333 = 0{,}75$$

$$\theta_p = 36{,}9°$$

15. You are designing eyeglasses for someone whose nearpoint is 60 cm. What focal length lens should you prescribe so that an object can be clearly seen when placed at 25 cm in front of the eye?

- [✓ a.] 43 cm
- b. -18 cm
- c. 18 cm
- d. -15 cm
- e. 60 cm

IMAGE AT 60 CM ; OBJECT AT 25 CM

VIRTUAL IMAGE (UPRIGHT) SO $q = -60$

$p = 25$ $\quad \frac{1}{25} + \frac{1}{-60} = \frac{1}{f} \quad f = 43$ cm

16. A given individual is unable to see objects clearly when they are beyond 100 cm. What focal length lens should be used to correct this problem?

- a. -20 cm
- b. 100 cm
- c. -33.3 cm
- [✓ d.] -100 cm
- e. 75 cm

OBJECTS AT ∞ SHOULD HAVE IMAGES AT 100 CM.

$\frac{1}{p} + \frac{1}{q} = \frac{1}{f} \quad p = \infty$ SO $q = f$

VIRTUAL IMAGE $\rightarrow q = -100 \rightarrow f = -100$ cm

17. In the normal eye the ciliary muscles that control the lens will relax:

- a. when viewing objects at a distance of 20 ft.
- b. in bright light.
- [✓ c.] when viewing objects at infinity.
- d. when viewing objects at the nearpoint.
- e. only when a person has his/her eyes closed.

18. A helium-neon laser ($\lambda = 632.8$ nm) is used to calibrate a diffraction grating. If the first-order maximum occurs at 20.50° with light incident normal to the grating, what is the line spacing, d?

- [✓ a.] 1.807×10^{-6} m
- b. 3.616×10^{-6} m
- c. 5.424×10^{-6} m
- d. 7.232×10^{-6} m
- e. 2.216×10^{-7} m

$$d \sin\theta = 1\lambda$$

$$d = \frac{632{,}8 \text{ nm}}{\sin 20{,}5°} = 1807 \text{ nm}$$

19. White light is spread out into spectral hues by a diffraction grating. If the grating has 2000 lines per cm, at what angle will red light (λ = 640 nm) appear in first order if the white light is incident normal to the grating?

a. 11.17°
b. 90.00°
[✓ c. 7.35°]
d. 3.57°
e. 13.35°

$m\lambda = d\sin\theta$ $\quad d = \frac{1\,cm}{2000}$ $\quad m = 1$

$\lambda = 640\ nm$ $\quad \sin\theta = \frac{640\times10^{-9}}{10^{-2}m/2000}$

$\sin\theta = .128$ $\quad \theta = 7.35°$

20. An unknown particle in an accelerator moving at a speed of 2.0 × 10^8 m/s has a measured relativistic mass of 2.0 × 10^{-26} kg. What must its rest mass be?

a. 0.65 × 10^{-26} kg
b. 0.81 × 10^{-26} kg
c. 1.01 × 10^{-26} kg
[✓ d. 1.49 × 10^{-26} kg]
e. 2.68 × 10^{-26} kg

RELATIVISTIC MASS $= \gamma m$

$\gamma = \frac{1}{\sqrt{1-v^2/c^2}}$ $\quad v = \frac{2}{3}c$ $\quad \gamma = \frac{1}{\sqrt{1-4/9}}$

$\gamma = \sqrt{\frac{9}{5}} = \frac{3}{\sqrt{5}} = 1.34$ $\quad \frac{2.0\times10^{-26}}{1.34}\,kg = 1.49\times10^{-26}\,kg$

21. A proton with rest mass of 1.67 × 10^{-27} kg moves in an accelerator with a speed of 0.8c . What is its total energy? (c = 3 × 10^8 m/s)

a. 0.54 × 10^{-10} J
b. 1.08 × 10^{-10} J
[✓ c. 2.51 × 10^{-10} J]
d. 3.26 × 10^{-10} J
e. 4.18 × 10^{-10} J

$\gamma mc^2 = E$ $\quad \gamma = \frac{1}{\sqrt{1-0.8^2}} = \frac{1}{0.6} = \frac{5}{3}$

$\frac{5}{3}(1.67\times10^{-27}kg)(3\times10^{8}m/s)^2 = 2.51\times10^{-10}J$

22. I observe a moving boxcar which has a mirror along the front wall but it is open at the back of the boxcar. I send a flash of light from my flashlight and time the flash of light as it goes to the front of the boxcar and returns to the back of the boxcar. A passenger riding at the back of the boxcar also times the flash of light as it passes him twice. Compare the times recorded on our watches.

[✓ a. The time recorded on his watch is shorter.]
b. The time recorded on the two watches is the same.
c. The time recorded on his watch is longer.
d. You can't say anything about it, because your reference frames are different.
e. None of the other answers are true.

23. A muon formed high in Earth's atmosphere travels at a speed 0.99*c* for a distance (as we see it) of 4.6 km before it decays. How far does the muon travel as measured in its frame?

a. 1298 m
b. 91.5 m
c. 2596 m
d. 4554 m
[✓ e.] 649 m

A HOMEWORK PROBLEM! $\gamma = \frac{1}{\sqrt{1-.99^2}} = 7.09$

$\frac{4.6\text{ km}}{7.09} = 0.649\text{ km}$

24. In a typical color television tube, the electrons are accelerated through a potential difference of 25,000 volts. What speed do the electrons have when they strike the screen? ($q_e = 1.6 \times 10^{-19}$ C, $m_e = 9.1 \times 10^{-31}$ kg, and $c = 3 \times 10^8$ m/s)

FROM THE STUDENT STUDY GUIDE! (AND ALMOST THE SAME AS A HW PROBLEM)

a. 0.15*c*
[✓ b.] 0.31*c*
c. 0.45*c*
d. 0.60*c*
e. 0.22*c*

KE = 25000 eV

$m_e c^2 = 0.511 \times 10^6$ eV

$E - E_0 = \gamma mc^2 - mc^2 = (\gamma - 1)mc^2 = KE$

$\gamma - 1 = 2.5\times10^4 / 0.511\times10^6 = .0489 \quad \gamma = 1.049$

$\rightarrow \gamma^2 = \frac{1}{1 - v^2/c^2}$

$\gamma^2 - \gamma^2 v^2/c^2 = 1$

$\frac{v^2}{c^2} = \frac{\gamma^2 - 1}{\gamma^2}$

$\frac{v^2}{c^2} = .0911$

$\frac{v}{c} = 0.302$

25. When the reflection of an object is seen in a convex mirror the image will:

a. always be real.
[✓ b.] always be virtual.
c. may be either real or virtual.
d. will always be magnified.
e. will always be inverted.