

\* Post Mon. 5/20\*

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Physics 104 Final Exam

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. A

2. D

3. C

4. B

5. E

6. At what point is the charge-per-unit area smallest on the surface of an irregularly shaped conducting solid?

a. at the average curvature

b. where surface curves inward

c. where surface is flat

d. where outward curvature is greatest

e. where outward curvature is ~~least~~ small.

NO  
CURVATURE

SLIGHT  
CURVATURE

GRAN  
CURVATURE.

7. In a thundercloud there may be an electric charge of +4 C near the top of the cloud and -4 C near the bottom of the cloud. These charges are separated by about 2 km. What is the electric force between these two sets of charges?

a.  $3.6 \times 10^4$  N

b.  $3.6 \times 10^5$  N

c.  $3.6 \times 10^6$  N

d.  $3.6 \times 10^7$  N

e.  $3.6 \times 10^6$  N

$$F = k q_1 q_2 / r^2 = \frac{9 \times 10^9 \times 4 \times 4}{(2 \times 10^3)^2}$$

$$= 4 \times 9 \times 10^3 = 3.6 \times 10^4 \text{ N}$$

8. Decreasing the separation of the two charged parallel plates of a capacitor which are disconnected from a battery will produce what effect on the capacitor?

a. decrease stored energy

b. increase charge

c. decrease charge

d. decrease capacitance

e. increase stored energy

DISCONNECTED  $\Rightarrow$  CHARGE Q  
CANNOT CHANGE.

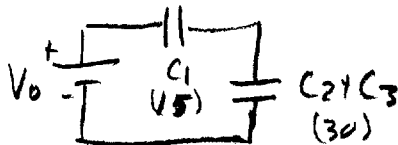
$$C = \epsilon_0 A / d \quad \text{SO IF } d \downarrow, C \uparrow$$

$$E = \frac{1}{2} \frac{Q^2}{C} ; \text{ IF } C \uparrow, E \downarrow$$

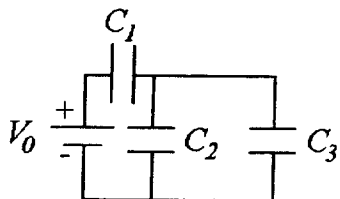
9. If  $C_1 = 15 \mu\text{F}$ ,  $C_2 = 10 \mu\text{F}$ ,  $C_3 = 20 \mu\text{F}$ , and  $V_0 = 18 \text{ V}$ , determine the energy stored by  $C_3$

- a. 0.72 mJ
- b. 0.36 mJ
- c. 0.50 mJ
- d. 0.18 mJ

$C_2 \neq C_3$  IN PARALLEL



CHARGE Q  
MUST BE SAME  
ON  $C_1$  AND  $(C_2 + C_3)$   
V SAME ON  $C_2 \neq C_3$



$Q = CV$  SO  $(C_2 + C_3) = 30$   
HAVE  $\frac{1}{2}$  AS MUCH VOLTAGE  
AS  $C_1 = 15$ , I.E. 6V

THEN  $C_3$  HAS 6V AND  $E = \frac{1}{2} CV^2 = \frac{1}{2} (20 \times 10^{-6}) (6)^2$

10. A wire carries a steady current of 0.1 A over a period of 200 s. What total charge passes through the wire in this time interval?  $= 20 \text{ C}$

- a. 20 C
- b. 200 C
- c. 2.0 C
- d. 300 C
- e. 0.005 C

$A = \text{COULOMBS/SEC}$

$0.1 \text{ A} \times 200 \text{ S} = 20 \text{ COUL.}$

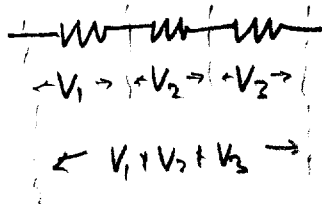
11. A high-voltage transmission line carries 1000 A at 990,000 V. What is the maximum power transmitted by the line?

- a. 370 MW
- b. 700 MW
- c. 100 MW
- d. 990 MW
- e. 70 MW

$P = IV = 1000 \times 990000$   
 $= 1 \times 10^3 \times 990 \times 10^3$   
 $= 990 \times 10^6 \text{ W}$

12. Three resistors connected in series have the individual voltages labeled  $V_1$ ,  $V_2$  and  $V_3$ , respectively. Which of the following expresses the total voltage across the three resistors when connected in this manner?

- a.  $V_t = V_1 + V_2 + V_3$
- b.  $V_t = (1/V_1 + 1/V_2 + 1/V_3)$
- c.  $V_t = V_1 = V_2 = V_3$
- d.  $V_t = (1/V_1 + 1/V_2 + 1/V_3)^{-1}$
- e.  $V_t = 0$



13. If  $E = 24\text{ V}$ , at what rate is thermal energy generated in the  $30\ \Omega$  resistor?

- a. 13 W
- b. 3.2 W
- c. 23 W
- d. 39 W
- e. 2.1 W

THE 15 & 30- $\Omega$  RESISTORS ARE IN PARALLEL

$$\frac{1}{R} = \frac{1}{15} + \frac{1}{30} = \frac{2}{30} \quad R = 15\ \Omega \text{ EQUIVALENT}$$

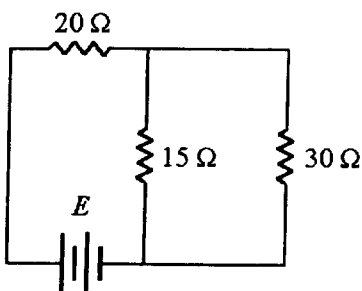
THESE 2 RESISTORS MUST HAVE

$$\frac{R}{R+20} \text{ OF THE VOLTAGE, OR}$$

$$\frac{1}{3} \times 24\text{V} = 8\text{V}, \quad P = IV \text{ AND}$$

$$V = IR \text{ SO } I = V/R \text{ AND } P = V^2/R$$

$$P = 8^2/30 = 64/30 = 2.1\text{ W}$$



14. A current in a solenoid with  $N$  turns creates a magnetic field at the center of that loop. The field strength is directly proportional to:

- a. number turns in loop
- b. the square of the current
- c. Choices A and B are valid
- d. current strength
- e. Choices A and D are valid

$$B = \mu_0 n I \quad n = \text{TURNS/UNIT LENGTH}$$

$\downarrow$  DISVALID  $\downarrow$  A IS VALID  
 $B$  IS NOT

15. Two long parallel wires 20 cm apart carry currents of 5A and 10A in the same direction. Is there any point between the two wires where the magnetic field is zero?

- a. Yes, 12 cm from the 5A wire.
- b. Yes, midway between the wires.
- c. Yes, 7.7 cm from the 5A wire.
- d. Yes, 6.7 cm from the 5A wire.
- e. No.

CURRENTS OUT OF PAPER



HERE THE B'S CANCEL

MAGNITUDE OF B IS

$\mu_0 I / 2\pi r$  SO B IS

THE SAME IF  $I/r$  IS

THE SAME; 2/3 OF THE

WAY FROM  $I = 10$  TO

$I = 5$ , 6.7 CM FROM

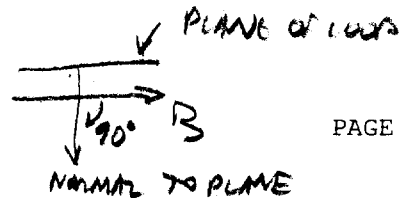
5A, SINCE

$$\frac{10A}{13.3\text{ CM}} = \frac{5A}{6.7\text{ CM}}$$

16. How is the energy stored in a current carrying inductor related to the current value,  $I$ ?

- a. directly proportional to  $I^2$
- b. directly proportional to  $I^{1/2}$
- c. directly proportional to  $I$
- d. inversely proportional to  $I$
- e. inversely proportional to  $I^2$

$$E = \frac{1}{2} LI^2, \quad a \text{ IS VALID}$$



17. A circular loop (area = 0.20 m<sup>2</sup>) turns in a uniform magnetic field with  $B = 0.13$  T. At an instant when the angle between the magnetic field and the normal to the plane of the loop is 90° and is increasing at the rate of 0.50 rad/s, what is the magnitude of the emf induced in the loop?

- a. 13 mV
- b. zero
- c. 26 mV
- d. 33 mV
- e. 20 mV

ROTATING LOOP  $\Rightarrow \Phi = BA \cos \theta$ ;  $\theta = \omega t = 90^\circ$

$$|E| = \frac{\Delta \Phi}{\Delta t} = BA \omega \sin \omega t = BA \omega \quad (\sin \omega t = 1)$$

$$= 0.13 \text{ T} \times 0.20 \text{ m}^2 \times 0.50 \text{ rad/s} = 0.013 \text{ V}$$

18. An ac series circuit contains a resistor of 20 Ohms, a capacitor of 0.75 microFarads and an inductor of 60 mH. What frequency should be used to create a resonance condition in the circuit?

- a. 318 Hz
- b. 159 Hz
- c. 750 Hz
- d. 4320 Hz
- e. 531 Hz

RESONANCE AT  $f = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{60 \times 10^{-3} \times 0.75 \times 10^{-6}}}$

$$f = \frac{1}{2\pi\sqrt{4.5 \times 10^{-8}}} = 750 \text{ Hz}$$

19. Which of the following effects is the result of the fact that the index of refraction of glass will vary with wavelength?

- a. mirages
- b. spherical aberration
- c. chromatic aberration
- d. birefringence
- e. light scattering

← DIFFERENT COLOR (COLOR = WAVELENGTH) RAYS FOCUS AT DIFFERENT DISTANCES.

20. Monochromatic light hits a piece of glass. What happens to the wavelength in the glass as the index of refraction decreases?

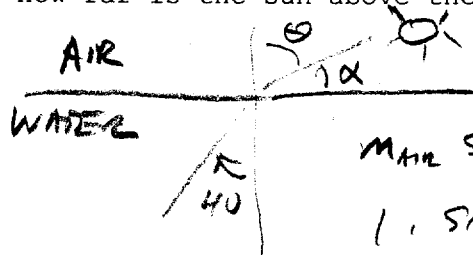
- a. increases
- b. decreases
- c. remains constant
- d. is zero
- e. approaches  $3 \times 10^8$  m

$f\lambda = c$  so  $f\lambda_n = c/n$  IN GLASS.

$$\lambda_n = c/fn; \text{ AS } n \downarrow \lambda_n \uparrow$$

21. An underwater scuba diver sees the sun at an apparent angle of 40° from the vertical. How far is the sun above the horizon? ( $n_{\text{water}} = 1.333$ )

- a. 13.8°
- b. 9.90°
- c. 19.5°
- d. 31.0°
- e. 27.0°



$$n_{\text{AIR}} \sin \theta = n_{\text{WATER}} \sin 40^\circ$$

$$1 \cdot \sin \theta = 1.333 \times 0.64$$

$$\sin \theta = 0.857$$

$$\theta = 59^\circ$$

$$\alpha = 90^\circ - \theta = 31^\circ$$

22. Sally places an object 6 cm from a thin convex lens along its axis. The lens has a focal length of 9 cm. What are the respective values of the image distance and magnification?

- a. 18 cm and 3
- b. -18 cm and 3
- c. 3 cm and -0.5
- d. -3 cm and 0.5
- e. -18 cm and -3

CONVEX LENS  $f = +9 > 0$   
 OBJECT AT  $p = 6 \text{ cm}$

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f} \Rightarrow \frac{1}{q} = \frac{1}{9} - \frac{1}{6} = \frac{2}{18} - \frac{3}{18} = -\frac{1}{18}$$

$$q = -18 \quad M = -q/p = +18/6 = 3$$

23. A candle is 49 cm in front of a convex spherical mirror of radius of curvature 70 cm. Where is the image and what is its magnification?

- a.  $q = -20.4 \text{ cm}$ ,  $M = +0.417$
- b.  $q = +20.4 \text{ cm}$ ,  $M = -0.417$
- c.  $q = 122.5 \text{ cm}$ ,  $M = +2.50$
- d.  $q = -20.4 \text{ cm}$ ,  $M = -0.417$
- e.  $q = 122.5 \text{ cm}$ ,  $M = -2.50$

CONVEX MIRRORS HAVE  $f = \frac{1}{2} R < 0$

SO  $f = -35$ ;  $p = 49$

$$\frac{1}{49} + \frac{1}{q} = -\frac{1}{35} \Rightarrow \frac{1}{q} = -\frac{1}{35} - \frac{1}{49} = -0.049$$

$$q = -20.4 \quad M = -q/p = +20.4/49 = 0.417$$

24. A Young's double slit apparatus is set up where a screen is positioned 0.8 m from the double slits. If the distance between alternating bright fringes is 0.83 cm and the light source has a wave length of 580 nm, what is the separation of the double slits?

- a.  $2.8 \times 10^{-5} \text{ m}$
- b.  $4.9 \times 10^{-5} \text{ m}$
- c.  $5.6 \times 10^{-5} \text{ m}$
- d.  $6.0 \times 10^{-5} \text{ m}$
- e.  $9.3 \times 10^{-5} \text{ m}$

$L = 0.8 \text{ m}$  For  $m=1$ ,  $y = 0.83 \text{ cm}$

$m\lambda = d \sin \theta \approx dy/L$  (SMALL ANGLE OK IF  $y \ll L$ ) SO  $d = \frac{L\lambda}{y} = \frac{0.8 \times 580 \times 10^{-9}}{0.83 \times 10^{-2}}$

$d = 5.6 \times 10^{-5} \text{ m}$

25. A possible means for making an airplane radar-invisible is to coat the plane with an antireflective polymer. If radar waves have a wavelength of 3 cm and the index of refraction of the polymer is  $n = 1.5$ , how thick would the coating be?

- a. 2 mm
- b. 1 mm
- c. 5 mm
- d. 10 mm
- e. 2 cm

PHASE SHIFT WHEN BOUNCING FROM METAL OR FROM POLYMER (BOTH) SO REQUIRE

$2t = \frac{1}{2} (\lambda/n)$  FOR CANCELLATION

$\Rightarrow 6t = \lambda = 3 \text{ cm} \quad t = 0.5 \text{ cm}$

26. The ciliary muscle of the eye is contracted under which condition?

- a. eye is focused on a nearby object
- b. eye is focused on a distant object ← THIS IS A RELAXED EYE
- c. subject being viewed is well illuminated.
- d. eye is shut
- e. subject being viewed is dimly illuminated

27. A binary star in the constellation Orion has an angular separation between the stars of  $10^{-5}$  radians. If  $\lambda = 500$  nm, what is the smallest aperture (diameter) telescope that will just resolve the two stars?

- a. 4.2 cm
- b. 3.0 cm
- c. 6.1 cm
- d. 140 cm
- e. 12.6 cm

$$\theta \approx 1.22 \lambda / D \quad D \approx 1.22 \lambda / \theta$$

$$D = 1.22 \times 500 \times 10^{-9} / 10^{-5} = 6.1 \times 10^{-2} \text{ m}$$

28. A tuning fork has a frequency of 400 Hz and hence the period of one cycle is  $2.5 \times 10^{-3}$  s. If the tuning fork is in an inertial frame of reference moving by the observer at speed of  $0.75c$ , what is the frequency of the fork as measured by the observer when the tuning fork is moving at right angles to the observer's line of sight (point of closest approach)? (Assume that measurements are strictly by optical means and that the speed of sound waves in air is not pertinent here.)

- a. 302 Hz
- b. 265 Hz
- c. 454 Hz
- d. 175 Hz
- e. 605 Hz

THINK OF THE TUNING FORK AS A TICKING CLOCK WHICH TICKS MORE SLOWLY BY  $\gamma = \frac{1}{\sqrt{1-v^2/c^2}}$

$$\gamma = \frac{1}{\sqrt{1-.75^2}} = 1.51 \quad 400 / 1.51 = 265$$

29. At what speed would a clock have to be moving in order to run at a rate that is one-half the rate of a clock at rest?

- a.  $0.67c$
- b.  $0.75c$
- c.  $0.87c$
- d.  $0.95c$
- e.  $0.93c$

↳ HERE  $\gamma = 2$  SO  $\frac{1}{\sqrt{1-v^2/c^2}} = 2 \quad \frac{1}{1-v^2/c^2} = 4$

$$1 = 4 - 4v^2/c^2 \quad 4v^2/c^2 = 3 \quad \frac{v^2}{c^2} = \frac{3}{4} \quad \frac{v}{c} = 0.87$$

30. Light of wavelength 450 nm is incident on a target metal which has a work function of 2.2 eV. What stopping potential is required for this combination in a phototube? ( $h = 6.63 \times 10^{-34}$  J-s,  $c = 3 \times 10^8$  m/s.  $1 \text{ eV} = 1.6 \times 10^{-19}$  J and  $1 \text{ nm} = 10^{-9}$  m)

- a. 0.96 V
- b. 0.56 V
- c. 2.76 V
- d. 0.32 V
- e. 4.56 V

$$E = hc / \lambda = \frac{1240 \text{ eV} \cdot \text{nm}}{450 \text{ nm}} = 2.76 \text{ eV}$$

$$\text{AVAILABLE KE} = E - \phi = 2.76 - 2.2 = 0.56 \text{ eV}$$

$$0.56 \text{ eV} = 1e \times \underline{0.56 \text{ V}}$$

(W = 9V)

31. How much energy (in eV) does a photon of red light ( $\lambda = 640 \text{ nm}$ ) have? ( $h = 6.626 \times 10^{-34} \text{ J}\cdot\text{s}$  and  $1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$ )

- a. 2.5 eV
- b. 0.9 eV
- c. 1.3 eV
- d. 3.2 eV
- e. 1.9 eV

$$E = \frac{hc}{\lambda} = \frac{1240 \text{ eV}\cdot\text{nm}}{640 \text{ nm}} = 1.9 \text{ eV}$$

32. Of the various wavelengths emitted from a hydrogen gas discharge tube, those associated with transitions from higher levels down to the  $n = 2$  level produce which of the following?

- a. microwaves
- b. X-rays
- c. ultraviolet
- d. infrared
- e. mixture of visible and near ultraviolet

THIS IS THE BALMER SERIES,  
THE VISIBLE HYDROGEN SPECTRUM  
(FOR  $n=2$ )

33. The wavelength of coherent ruby laser light is 688.3 nm. What energy difference (in eV) exists between the upper state and the lower state of the transition producing this light?

- a. 1.80 eV
- b. 1.99 eV
- c. 1.93 eV
- d. 1.74 eV
- e. 1.86 eV

$$E = \frac{hc}{\lambda} = \frac{1240 \text{ eV}\cdot\text{nm}}{688.3 \text{ nm}} = 1.80 \text{ eV}$$

34. The alpha radiation first detected by Becquerel was in fact which of the following?

- a. high energy quanta
- b. neutrinos
- c. positrons
- d. helium nuclei  $\leftarrow \alpha$ -PARTICLES
- e. electrons

35. A 1-gram sample of petrified wood is taken from a petrified forest. If the Carbon-14 activity of the sample is 20% that of present-day organic material, what is the age of the petrified wood? ( $T_{1/2}$  for C-14 is 5,730 years)

- a. 8,600 years
- b. 2,230 years
- c. 17,200 years
- d. 4,460 years
- e. 13,300 years

$$20\% = 0.20 = \left(\frac{1}{2}\right)^{t/T_{1/2}}$$

$$\log(0.20) = \frac{t}{T_{1/2}} \log\left(\frac{1}{2}\right)$$

$$t = T_{1/2} \frac{\log 0.20}{\log 2} = 5730 \frac{(-1.61)}{(-0.693)}$$

$$t = 1.33 \times 10^4$$

36. Which of the following will not influence the rate at which nuclear reactions will occur in a nuclear power plant where the fuel elements are a mixture of U-235 and U-238?

- a. The presence of control rods ✓
- b. The percentage of the energy that is used to produce electricity** ← THIS IS AFTER THE ENERGY IS GENERATED, AND SEPARATE FROM THE NUCLEAR REACTIONS.
- c. The presence of moderating material ✓
- d. The percentage of U-235 relative to U-238 ✓
- e. All will affect the rate X

37. The pion ( $m = 135 \text{ MeV}/c^2$ ) is thought to be the particle exchanged in the nuclear force. What is the maximum range of this particle if its "time of existence" is as long as can be allowed by the uncertainty principle? ( $\hbar = 1.054 \times 10^{-34} \text{ J-s}$ )

- ~~a.  $1.2 \times 10^{-15} \text{ m}$~~
- ~~b.  $1.5 \times 10^{-15} \text{ m}$~~
- ~~c.  $2.0 \times 10^{-15} \text{ m}$~~
- ~~d.  $7.5 \times 10^{-15} \text{ m}$~~
- ~~e.  $9.0 \times 10^{-15} \text{ m}$~~
- a.  $10^{-20} \text{ m}$
- b.  $10^{-16} \text{ m}$**
- c.  $10^5 \text{ m}$
- d.  $10^{10} \text{ m}$
- e.  $10^{-10} \text{ m}$

REST ENERGY IS

$$E = mc^2 = 135 \text{ MeV}$$

USE THIS IN UNCERTAINTY RELATION TO FIND LIFETIME.

$$\Delta E \Delta t \sim \frac{\hbar}{4\pi} = \frac{1.054 \times 10^{-34}}{2}$$

$$\Delta t \sim \frac{1.054 \times 10^{-34}}{2 \times 135 \times 10^6 \text{ eV} \times 1.6 \times 10^{-19} \text{ J/eV}}$$

$$\Delta t \sim 1.22 \times 10^{-24} \text{ s}$$

$$\text{RANGE} \sim c \Delta t = 3.65 \times 10^{-16} \text{ m}$$

c IS THE FASTEST IT CAN GO SO IT HAS A RANGE OF ABOUT  $c \Delta t$ .

IT CAN EXIST FOR  $\Delta t$  BECAUSE FOR TIME  $\Delta t$  THERE IS UNCERTAINTY ABOUT ENERGY  $\Delta E$ . IF  $\Delta E$  IS AS BIG AS THE REST MASS OF A PARTICLE, THEN FOR A  $\Delta t$  TIMES PAN THE PARTICLE CAN APPEAR AND DISAPPEAR WITHOUT VIOLATING CONSERVATION OF ENERGY.