EXAM 3 PHYS 103 Key Spring 2013 **A**

NAME: ______________________________ SECTION__________

As a student at NJIT I ______________________, will conduct myself in a professional manner and will comply with the provisions of the NJIT Academic Honor Code. I also understand that I must subscribe to the following pledge on major work submitted for credit as described in the NJIT Academic Honor Code: On my honor, I pledge that I have not violated the provisions of the NJIT Academic Honor Code.

Answer each question on the Scantron card using #2 pencil. Also circle your answers on the question papers. SHOW HOW YOU GOT YOUR ANSWERS ON THE EXAM SHEETS. Use the back if necessary.

1. A very loud train whistle has an acoustic power output of 100 W. If the sound energy spreads out spherically, what is the intensity level in dB at a distance of 100 meters from the train? ($I_0 = 10^{-12}$ W/m^2)

a. 78.3 dB
b. 81.6 dB
[✓ c. 89.0 dB]
d. 12.6 dB
e. 95.0 dB

$I = \frac{P}{4\pi R^2} = \frac{100w}{4\pi(100)^2} = 7.96\times10^{-4}\ w/m^2$

$\beta = 10\log(I/I_0) = 10\log\left(\frac{7.96\times10^{-4}}{10^{-12}}\right) dB$

$= 89dB$

2. How far away is a lightning bolt if it takes 10 s for the sound of the associated thunder to reach the observer (assume that the velocity of sound is 343 m/s and that 1.60 km = 1 mile)?

a. 1 mile
[✓ b. 2 miles]
c. 8 miles
d. 5 miles
e. 10 miles

$V = \Delta X/\Delta t$

$\Delta X = V\times\Delta t = (343 m/s)(10 sec) * \frac{1km}{1000m} * \frac{1 mi}{1.6km}$

$= 2.1 mi$

3. A 500-Hz whistle is moved toward a listener at a speed of 10.0 m/s. At the same time, the listener moves at a speed of 20.0 m/s in a direction away from the whistle. What is the apparent frequency heard by the listener? (The speed of sound is 340 m/s.)

a. 473 Hz
b. 376 Hz
[✓ c. 485 Hz]
d. 533 Hz
e. 547 Hz

$f = f_0 \frac{V+V_d}{V-V_s} \longrightarrow 500 * \frac{340-20}{340-10}$

$= 485Hz$

4. A flute behaves like a tube open at both ends. If its length is 65.3 cm, and the speed of sound is 340 m/s, what is its fundamental frequency in Hz?

a. 130 Hz
b. 124 Hz
c. 159 Hz
[✓ d. 260 Hz]
e. 212 Hz

$f_n = \frac{nV}{2L}$ $n=1$ fundamental frequency

$f_1 = \frac{(1)(340 ms)}{2(0.653)} = 260Hz$

5. Two loudspeakers are placed next to each other and driven by the same source at 500 Hz. A listener is positioned in front of the two speakers and on the line separating them, thus creating a constructive interference at the listener's ear. What minimum distance would one of the speakers be moved back away from the listener to produce destructive interference at the listener's ear? (The speed of sound = 340 m/s.)

a. 1.36 m
b. 0.68 m
[✓ c.] 0.34 m
d. 0.17 m
e. 0.12 m

$\lambda = v/f$

$x = (n + \frac{1}{2}\lambda)$ destructive interference

$n = 0$

$x = \frac{\lambda}{2} = \frac{v}{2f} = \frac{340}{2(500)}$
$= 0.340\text{m}$

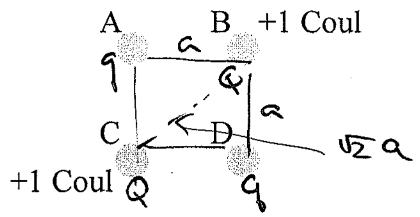
6. Two point charges, separated by 1.5 cm, have charge values of +4.0 and –4.0 μC, respectively. What is the value of the mutual force between them? ($k_e = 8.99 \times 10^9$ N·m²/C²)

[✓ a.] 640 N
b. 3.6×10^{-8} N
c. 8.0×10^{-12} N
d. 2.0×10^{-12} N
e. 6.4×10^{14} N

$$F = \frac{q_1 q_2 k}{r^2} = \frac{4\times10^{-6} * 4\times10^{-6}}{(0.015\text{m})^2} 8.99\times10^9 \text{ N}$$

$= 640\text{N}$

7. Four charges are at the corners of a square, with B and C on opposite corners. Charges A and D, on the other two corners, have equal charge, while both B and C have a charge of +1.0 C. What is the charge on A so that the force on B is zero?



a. –1.0 C
b. –0.50 C
c. –0.35 C
d. –0.71 C
[✓ e.] –0.25C

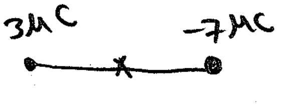
$$F_B = \frac{Q^2 k}{2a^2} + \frac{qQ}{a^2} * 2k = 0$$

$$\frac{Q^2 \cancel{k}}{\cancel{2a^2}} + \frac{qQ2\cancel{k}}{\cancel{a^2}} = 0$$

$$\frac{Q^2}{2} + 2qQ = 0 \rightarrow \frac{Q}{2} + 2q = 0 \Rightarrow q = -\frac{Q}{4}$$

8. Two point charges are placed along a horizontal axis with the following values and positions: +3.0 μC at x = 0 cm and –7.0 μC at x = 20 cm. What is the electric field at x=10 cm?

a. 3.60×10^6 N/C
b. 5.20×10^2 N/C
c. 8.30×10^9 N/C
d. 230 N/C
[✓ e.] -3.60×10^6 N/C



$E = qk/r^2$

$$E(x) = \frac{3\times10^{-6} * 8.99\times10^9}{(0.1)^2} - \frac{7.0\times10^{-6} * 8.99\times10^{+9}}{0.1^2}$$

$= -3.6 \times 10^6$

9. A proton initially moves left to right long the x axis at a speed of 2.00×10^3 m/s. It moves into an electric field, which points in the negative x direction, and travels a distance of 0.55 m before coming to rest. If the proton's mass and charge are 1.67×10^{-27} kg and 1.60×10^{-19} C respectively, what is the magnitude of the electric field?

   a. 28.3 N/C
   b. 13.9 N/C
   c. 0.104 N/C
   d. 0.304 N/C
   [✓ e.] 0.038 N/C

$$\left.\begin{aligned} V_f^2 &= V_i^2 + 2a(x_f - x_i) \\ &= V_i^2 + 2a\,\Delta x \end{aligned}\right\} \longrightarrow a = \frac{V_f^2 - V_i^2}{2\Delta x}$$

$$\left.\begin{aligned} F &= ma \\ F &= qE \end{aligned}\right\} \Rightarrow E = F/q = \frac{ma}{q} = \frac{m}{q}\left(\frac{V_f^2 - V_i^2}{2\Delta x}\right)$$

$$E = \frac{1.67 \times 10^{-27}}{1.6 \times 10^{-19}} * \left(\frac{0 - (2 \times 10^3)^2}{2(0.55)}\right)$$

$$= \underline{0.038 \text{ N/C}}$$

10. The current in an electron beam in a cathode-ray tube is measured to be 70 μA. How many electrons hit the screen in 5.0 s? ($e = 1.6 \times 10^{-19}$ C)

   a. 2.2×10^{11} electrons
   b. 8.8×10^{13} electrons
   [✓ c.] 2.2×10^{15} electrons
   d. 3.2×10^{14} electrons
   e. 8.8×10^{18} electrons

$$n_{elect} = \frac{70 \times 10^{-6} \text{ C/s} * 5 \text{ s}}{1.6 \times 10^{-19} \text{ C/elect}}$$

$$= 22 \times 10^{15} \text{ elect}$$

11. A high voltage transmission line of diameter 2 cm and length 200 km carries a steady current of 1 000 A. If the conductor is copper with a free charge density of 8×10^{28} electrons/m^3, how long does it take one electron to travel the full length of the cable? ($e = 1.6 \times 10^{-19}$ C)

   a. 8×10^2 s
   b. 8×10^4 s
   c. 8×10^7 s
   d. 8×10^6 s
   [✓ e.] 8×10^8 s

$$I = nqV_d A$$

$$V_d = I/nqA = \frac{1000 \text{ A}}{(8 \times 10^{28}/\text{m}^3)(1.6 \times 10^{-19})\,\pi(1 \times 10^{-2}\text{ m})^2}$$

$$= 2.49 \times^{-4} \text{ m/s}$$

$$\Delta t = \frac{\Delta x}{V} = \frac{200 \times 10^3 \text{ m}}{2.49 \times 10^{-4} \text{ m/s}} = 8 \times 10^8 \text{ sec}$$

12. A metallic conductor has a resistivity of 18×10^{-6} $\Omega \cdot$m. What is the resistance of a piece that is 30 m long and has a uniform cross sectional area of 3.0×10^{-6} m^2?

   a. 0.056 Ω
   [✓ b.] 180 Ω
   c. 120 Ω
   d. 160 Ω
   e. 90 Ω

$$R = \frac{\rho L}{A} = \frac{(18 \times 10^{-6}\,\Omega \cdot \text{m})(30)}{3.0 \times 10^{-6}}$$

$$= 180\ \Omega$$

13. A 500-W heater carries a current of 4.0 A. How much does it cost to operate the heater for 30 min if electrical energy costs 6.0 cents per kWh?

[✓ a.] 1.5 cents
b. 9.0 cents
c. 18 cents
c. 27 cents
d. 36 cents

$1 \text{ kwhr} = (1000 \text{w})(3600 \text{s}) = 3.6 \times 10^6 \text{ J}$

$E = 500 \text{W} * 30 \text{ min} * 60 \text{ s/min} = 900{,}000 \text{ J}$

$900{,}000 \text{J} * \frac{6 \text{cents}}{3.6 \times 10^6 \text{J}} = 1.5 \text{ cents}$

14. A steam turbine at an electric power plant delivers 4 500 kW of power to an electrical generator which converts 95% of this mechanical energy into electrical energy. What is the current delivered by the generator if it delivers at 3 600 V?

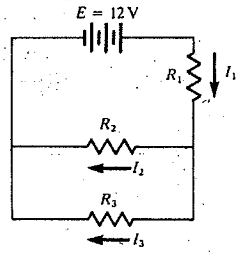
a. 0.66×10^3 A
b. 1.0×10^3 A
[✓ c.] 1.2×10^3 A
d. 3.2×10^3 A
e. 5.9×10^3 A

$P_{output} = \text{Efficiency} * P_{in}$
$= (0.95)\ 4500 \text{kW}$

$\text{Power} = I V \qquad I = \frac{P_{out}}{V_{out}} = \frac{0.95 * 4500 \times 10^3 \text{w}}{3600 \text{V}} = 1.2 \times 10^3 \text{A}$

15. What is the approximate current, I, in the diagram below (R_1= 25 Ω, R_2=50 Ω and R_3= 100 Ω)?

a. 1.03 A
b. 3.51 A
[✓ c.] 0.21 A
d 0.52 A
e. 2.78 A



total current I = ?

$R_{eq} = 25 + \frac{1}{\frac{1}{50} + \frac{1}{100}} = 58.3$

$I = \frac{V}{R_{eq}} = \frac{12}{58.3} = 0.206 \text{ A}$

16. What is the approximate current, I_2, in the diagram in the previous problem?

[✓ a] 0.14 A
b. 4.27 A
c. 0.28 A
d 0.54 A
e. 1.74 A

$R_1 = 25 \Omega$

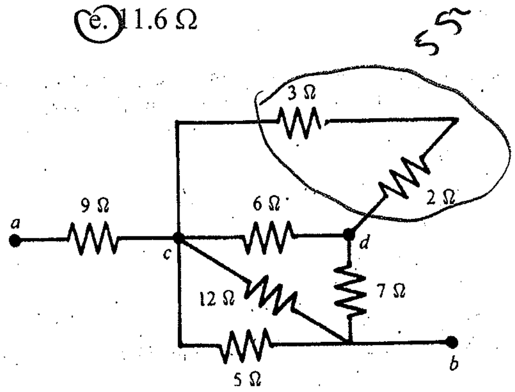
$(R_{eq})_1 = \frac{1}{\frac{1}{50} + \frac{1}{100}} = 33.3 \Omega$

$\Delta V = I * (R_{eq})_1 = 0.206 * 33.3 \text{A}$
$= 6.87 \text{V}$

$I_2 = \frac{V}{R_2} = \frac{6.87 \text{v}}{50 \Omega} = 0.14 \text{A}$

17. The equivalent resistance between points a and b in the figure below is apriximately:

a. 5.2 Ω
b. 37.3 Ω
c.17.9 Ω
d. 23 Ω
[✓ e. 11.6 Ω]



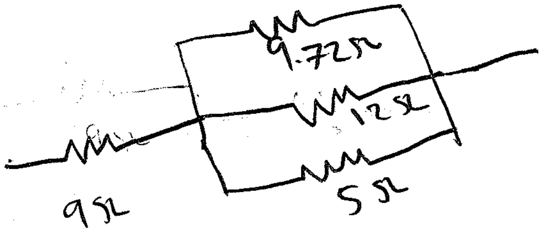
① 3+2 → 5Ω

② 5Ω in parallel with 6Ω.

$(1/5 + 1/6)^{-1} \rightarrow 2.72\,\Omega$

③ 2.72 + 7 → 9.72Ω

④



$= 9\Omega + (1/9.72 + 1/12 + 1/5)$

$= 11.6\ \Omega$

Equation Sheet

Waves: $v = \lambda \cdot f$ linear mass: $\mu = \frac{m}{L}$ $v = \sqrt{\frac{F}{\mu}} = \sqrt{\frac{Tension}{\mu}}$

sound: $v = 343$ m/s $v = 331$ m/s $\sqrt{\frac{T}{273\,K}}$

$I_0 = 10^{-12}$ W/m^2 $I = \frac{E}{t \cdot A}$ $I = \frac{P}{4\pi R^2}$ $\beta = 10\text{dB} \log\frac{I}{I_0}$ $\beta_2 - \beta_1 = 10\text{dB} \log\frac{I_2}{I_1}$ $f = f_0 \frac{v_{sound} \pm v_d}{v_{sound} \mp v_s}$

standing waves: on string and in open pipe at both ends: $n = 1, 2, 3.,$ $f = \frac{v}{2L} n$ $\lambda = \frac{2L}{n}$

in pipe closed at one end: $n = 1, 3, 5, \ldots$ $f = \frac{v}{4L} n$ $\lambda = \frac{4L}{n}$

interference: constructive: $d_2 - d_1 = n\lambda$ $f = \frac{v}{d_2 - d_1} n$ destructive: $d_2 - d_1 = (n + ½)\lambda$ $f = \frac{v}{d_2 - d_1}(n + ½)$

Electric charge: $q = Ne$ $F = k\frac{q_1 q_2}{r^2}$ $E = k\frac{q}{r^2}$ $F = qE$ $qE = ma$

$k = 8.99 \times 10^9$ Nm^2/C^2 $e = 1.6 \times 10^{-19}$ C $m_e = 9.11 \times 10^{-31}$ kg Circuits: $R = \rho\frac{L}{A}$;

$R = R_0[1 + \alpha(T - T_0)]$; $V = I{*}R$ $I = \frac{\Delta q}{\Delta t} = \frac{Ne}{t}$; $Q = mc\Delta T$ $P = \frac{E}{\Delta t}$ $P = I^2 R$

$P = \frac{V^2}{R}$ $P = I{*}V$; in series : $R_{eq} = R_1 + R_2 + \ldots + R_n$ in parallel: $1/R_{eq} = 1/R_1 + 1/R_2 + \ldots + 1/R_n$

$I = n\,q\,v_d A$

Motion for constant acceleration

$x = v_0 t + \frac{1}{2} a t^2$ $x_f = x_i + \frac{v_f^2 - v_i^2}{2a}$ $v = v_o + at$;

$F = m\,a$