1. A sound wave in air \( (v_{\text{sound}} = 344 \text{ m/sec}) \) hits a wall made of wood \( (v_{\text{sound}} = 1000 \text{ m/sec}) \) which contains a window made of glass \( (v_{\text{sound}} = 700 \text{ m/sec}) \). Which material will \textbf{reflect} a higher percentage of the wave's energy?

A) Wood       B) Glass       C) Equal       D) No reflection occurs from either material

2. Two point charges (one positive and one negative) are released from rest near each other. Which of the following is true during the time they are approaching each other?

A) Potential Energy becomes more negative; Attractive force becomes stronger
B) Potential Energy becomes more negative; Attractive force becomes weaker
C) Potential Energy becomes more positive; Attractive force becomes stronger
D) Potential Energy becomes more positive; Attractive force becomes weaker

3. Which of the following devices do \textbf{NOT} commonly use capacitors?

A) High-powered lasers       B) Computer keyboards       C) Electric heaters       D) Microphones

4. A 9-V battery drives current through a circuit containing 5 identical light bulbs, connected in series. If we add one more light bulb in series, the power used by the entire circuit will:

A) Increase       B) Decrease       C) Stay the same       D) Increase or decrease; answer depends on the resistance of the new bulb

**PROBLEMS 5-7 REFER TO THE SITUATION DESCRIBED BELOW:**

A simple vacuum-filled parallel-plate capacitor has a plate area of 1.0 cm\(^2\) and plate separation of 0.1 mm. Each plate has a surface charge density of \(10^6 \text{ C/m}^2\) (one plate positive and one plate negative). The capacitor is \textbf{NOT} connected to a battery.

5. What is the voltage difference between the plates?

A) 0.112 V       B) 1.12 V       C) 11.2 V       D) 112 V

6. How much potential energy is stored in the capacitor?

A) \(5.6 \times 10^{-7} \text{ J}\)       B) \(5.6 \times 10^8 \text{ J}\)       C) \(5.6 \times 10^9 \text{ J}\)       D) \(5.6 \times 10^{-10} \text{ J}\)

7. A material with dielectric constant \(K\) is inserted to fill the gap between the plates. What is the ratio of the new capacitor energy to the old capacitor energy?

A) \(K\)       B) \(K^2\)       C) \(1/K\)       D) \(1/K^2\)
PROBLEMS 8-10 REFER TO THE SITUATION DESCRIBED BELOW:

A heating element in a toaster is a cylinder with length 10 cm and cross-sectional area 1.0 cm². It is made of a material with a resistivity of 5 Ω·m. A current of 10 mA is passed through the heating element.

8. What is the voltage drop across the heating element?
   A) 5 V          B) 50 V          C) 500 V          D) 5000 V

9. How long will it take for the heating element to release 20 J of heat energy to the surroundings?
   A) 1 sec       B) 10 sec       C) 20 sec       D) 40 sec

10. Another cylindrical heating element is made from the same material, but has half the length and half the diameter of the original element. It is connected in series with the original element. What is the total resistance of the combination?
    A) 5000 Ω     B) 7500 Ω     C) 10000 Ω   D) 15000 Ω

PROBLEMS 11-12 REFER TO THE SITUATION DESCRIBED BELOW:

An pipe in a musical instrument is closed at one end and open at the other end.

11. For standing sound waves, which of the following is true about the closed end of the pipe?
    A) Displacement node and pressure node  
    B) Displacement node and pressure antinode  
    C) Displacement antinode and pressure node  
    D) Displacement antinode and pressure antinode

12. Which series of numbers describes the harmonic frequencies of the pipe (measured as a ratio with the fundamental frequency)?
    A) 1, 2, 3, 4, …   B) 1, 2, 4, 8, ..   C) 1, 3, 5, 7, …   D) 1, 4, 9, 16, ...

PROBLEMS 13-14 REFER TO THE SITUATION DESCRIBED BELOW:

A police car is chasing a suspect. The police siren has a frequency of 344 Hz. Assume \( v_{\text{sound}} = 344 \text{ m/sec} \)

13. The police car travels at 30 m/sec, and the suspect's motorcycle travels at 20 m/sec (both speeds measured relative to the road). What frequency does the suspect hear as the siren wails?
    A) 335 Hz   B) 345 Hz   C) 355 Hz   D) 399 Hz

14. The suspect is now trapped against a wall (both the police car and suspect are standing still). The police car is 5 m from the wall. At which of the following distances from the wall can the suspect stand to hear constructive interference between the siren and its reflection from the wall?
    A) 1.0 m   B) 2.0 m   C) 2.25 m   D) 3.5 m
PROBLEMS 15-16 REFER TO THE SITUATION DESCRIBED BELOW:

A point charge (+5 C) is 1.0 m away from another point charge (-3 C). Both are fixed in position.

15. There is one point in space where the total electric field due to these two charges will be zero. How far is this point from the -3 C charge?

A) 3.44 m  B) 1.6 m  C) 0.44 m  D) 0.67 m

16. What is the electric potential (voltage) at the midpoint between the two charges? (treat V=0 as infinitely far away from the charges)

A) $1.8 \times 10^9$ V  B) $3.6 \times 10^9$ V  C) $1.8 \times 10^{10}$ V  D) $3.6 \times 10^{10}$ V

PROBLEMS 17-19 REFER TO THE SITUATION DESCRIBED BELOW:

An initially uncharged capacitor (C = 5 mF) is being charged by a battery (ε = 10 V) with internal resistance (r = 10 Ω). Assume that wires have negligible resistance.

17. What is the voltage drop across the capacitor at t = 25 msec?

A) 0.0 V  B) 2.8 V  C) 5.0 V  D) 3.9 V

18. How long into the charging process will the capacitor have half of its final stored energy?

A) 0.025 sec  B) 0.061 sec  C) 0.071 sec  D) 0.094 sec

19. What is the total energy dissipated by the internal resistor during the entire charging process?

A) 125 mJ  B) 250 mJ  C) 500 mJ  D) 1000 mJ

PROBLEMS 20-21 REFER TO THE CIRCUIT DRAWN BELOW:

Assume the battery has zero internal resistance.

20. What is the current through the 3Ω resistor?

A) 0.83 A  B) 1.21 A  C) 1.60 A  D) 0.45 A

21. What is the total power used by this circuit?

A) 5.0 W  B) 7.1 W  C) 9.1 W  D) 12.3 W
PROBLEMS 22-23 REFER TO THE CIRCUIT DRAWN BELOW:

Assume this circuit has been connected for a long time (i.e. all capacitors are fully charged)

22. Calculate the charge on the 20 μF capacitor.
   A) 60 μC    B) 120 μC    C) 180 μC    D) 240 μC

23. Which of the following equations relating the capacitor voltages is true? (The subscripts refer to the capacitor across which the voltage drops are measured.)
   A) \( V_{20} = V_{30} + V_3 \)    B) \( V_{20} + V_{30} - V_3 = 10 \text{ V} \)    C) \( V_{20} + V_{30} = 10 \text{ V} \)    D) \( V_{20} = V_3 \)

PROBLEMS 24-25 REFER TO THE CIRCUIT DRAWN BELOW:

There are two batteries (6 V and 3 V), each of which has an internal resistance of 1 Ω. The internal resistances are shown in the diagram (you don't need to add them separately).

24. What is the current through the 3 Ω resistor?
   A) 0.67 A    B) 0.79 A    C) 0.91 A    D) 1.15 A

25. What is the terminal voltage across the 3 V battery? (remember to include the internal resistor)
   A) 2.11 V    B) 2.46 V    C) 2.74 V    D) 2.95 V

MAKE SURE YOU HAVE MARKED YOUR EXAM VERSION ON YOUR SCANTRON SHEET.

PLEASE HAVE YOUR PICTURE I.D. READY WHEN YOU TURN IN THE EXAM.

HAVE A GREAT WINTER BREAK!
FORMULAS

\[ k = \frac{1}{4\pi \varepsilon_0} \approx 9.0 \times 10^9 \frac{Nm^2}{C^2} \]
\[ \varepsilon_0 = 8.85 \times 10^{-12} \frac{C^2}{Nm^2} \]
\[ I \propto \frac{1}{r^2} \quad \beta = 10 \log_{10} \left( \frac{I}{I_0} \right) \]
\[ v = \lambda f \]
\[ \lambda_n = \frac{2L}{n} \]
\[ f_{\text{max}} = |f_1 - f_2| \]
\[ \Delta L = m \lambda \]
\[ \Delta L = (m + \frac{1}{2}) \lambda \]
\[ \phi_E = \frac{q_{\text{enclosed}}}{\varepsilon_0} \]
\[ \phi_s = \oint \vec{E} \cdot d\vec{A} \]
\[ \vec{E} = \vec{\nabla} V \]
\[ Q = CV \]
\[ E_{\text{plasma}} = \frac{\sigma}{2\varepsilon_0} \]
\[ U = \frac{1}{2} CV^2 \]
\[ U = \frac{Q^2}{2C} \]
\[ D V_{\text{battery}} = \varepsilon - Ir \]
\[ V = IR \]
\[ P = I^2 R \]
\[ P = \frac{V^2}{R} \]
\[ R = \frac{\rho L}{A} \]
\[ R_{\text{tot}} = R_1 + R_2 \]
\[ R_{\text{tot}} = \left( \frac{1}{R_1} + \frac{1}{R_2} \right)^{-1} \]
\[ C_{\text{tot}} = C_1 + C_2 \]
\[ C_{\text{tot}} = \left( \frac{1}{C_1} + \frac{1}{C_2} \right)^{-1} \]
\[ \Sigma I_m = \Sigma I_{\text{ext}} \]
\[ \Sigma (\Delta V) = 0 \]
\[ Q(t) = Q_0 (1 - e^{-t/RC}) \]
\[ Q(t) = Q_0 e^{-t/RC} \]
\[ I = \pm \frac{dQ}{dt} \]