KEY

AP® Physics 1
Super Review Packet 4

WAVES and Sound (WITH SOME PENDULUM AND SPRINGS THROWN IN)

$T_p = 2\pi\sqrt{\frac{L}{g}}$ ← will change

1. A simple pendulum and a mass hanging on a spring both have a period of 1s when set into small oscillatory motion on Earth. They are taken to Planet X, which has the same diameter (same volume) as Earth but twice the mass. How do the periods compare?

$2\cdot g = \frac{GM\cdot 2}{R^2}$

mass-spring has the same period $T = 2\pi\sqrt{\frac{m}{k}}$

The pendulum's period is shorter by $T \propto \frac{1}{\sqrt{2}}$ due to twice the acceleration of gravity!

2. A 10kg mass is attached to a string of length 40m, and hung down from a rooftop to make a long pendulum. If the pendulum is set into simple harmonic motion, what is its period of vibration?

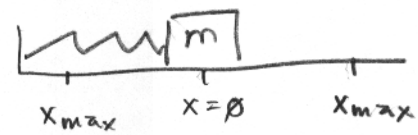
$T_p = 2\pi\sqrt{\frac{L}{g}} = 2\pi\sqrt{\frac{40}{10}} = 4\pi\ s$ mass matters not!

3. A certain vibrating string has two successive harmonics of frequencies of 250Hz and 300Hz. If the speed of the wave on the string is 100m/s, the length of the string is closest to which of the following?

$f_n = \frac{nv}{2L}$ $f_1 = 300 - 250 = 50Hz$ $L = \frac{nv}{2f_1} = \frac{1(100)}{2(50)} = 1m$

4. A mass is attached to a spring and set into simple harmonic motion. Describe when the following values are at a maximum. (Net force, acceleration, velocity, Potential energy, Kinetic energy)

$x = \emptyset$ $x = max$ $x = \emptyset$ $x = max$ $x = \emptyset$



5. Two strings sound two different frequencies, and a third frequency (created due to interference of the two original waves) of 100Hz is detected. If the lower string vibrates with a frequency of 300Hz, what must be the frequency of the second string?

$f_{beat} = |f_1 - f_2|$ $f_2 = f_{beat} + f_1 = 100Hz + 300Hz = 400Hz$

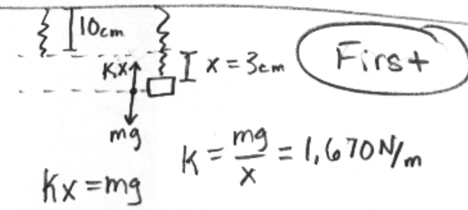
6. A pipe closed at one end has a length of 2m. If the conditions of the air in the pipe are such that the speed of sound in the air is 400m/s, what are the frequencies of the first two harmonics for the pipe?

$f_n = \frac{nv}{4L}$ $v = 400m/s$ $L = 2m$ $f_1 = \frac{1(400)}{4(2)} = 50Hz$ $f_2 = \frac{2(400)}{4(2)} = 100Hz$

7. A 5kg mass is hung from a 10cm-long vertically-oriented spring, and stretches the spring an additional 3cm from equilibrium. Now when the mass is replaced by a 27kg mass, what is the total length of the stretched spring?

Second

$Total = 16cm + 10cm = 26cm$ $y = 16cm$ $ky = Mg$ $y = \frac{Mg}{k}$ $y = 0.16m$



$kx = mg$ $k = \frac{mg}{x} = 1{,}670 N/m$

8. An organ pipe is open on both ends. The frequency of some particular harmonic is 720Hz, and the frequency of the next higher harmonic is 800Hz. Assuming the speed of sound in the air in the pipe to be 345m/s, what is the length of the pipe?

$f_n = \frac{nv}{2L}$ $800 - 720 = 80Hz = n_1$ $L = \frac{nv}{2f_1} = \frac{1(345)}{2(80)} = 2.2m$

9. A spring of constant K is connected to a mass M, making a horizontal massspring system. It is then stretched back a distance D from equilibrium, and set into motion.

A. What is the total amount of energy stored in the system?
B. What is the maximum speed of the system?
C. What is the maximum restoring force for the system?
D. What is the period of vibration for the system?
E. Find the equation that describes the mass's location as a function of time.

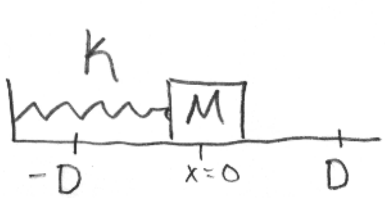
A) $U_s = \frac{1}{2}KD^2$

B) COE $\frac{1}{2}KD^2 = \frac{1}{2}MV^2$ $V = \sqrt{\frac{KD^2}{M}}$

C) $F_s = KD$

D) $T = 2\pi\sqrt{\frac{M}{K}}$

E) $X = D\cos(\omega t)$



AP Physics B Waves & Interference Exam J (57min) **Name**______________________________ **Per**___

__C__ 1) If the mass of a simple pendulum is doubled but its length remains constant, its period is multiplied by a factor of

(A) $\frac{1}{2}$

(B) $\frac{1}{\sqrt{2}}$

(C) 1

(D) $\sqrt{2}$

(E) 2

$T_p = 2\pi\sqrt{l/g}$

__D__ 2) Which of the following is true for a system consisting of a mass oscillating on the end of an ideal spring?

(A) The kinetic and potential energies are equal at all times.
(B) The kinetic and potential energies are both constant.
(C) The maximum potential energy is achieved when the mass passes through its equilibrium position.
(D) The maximum kinetic energy and maximum potential energy are equal, but occur at different times.
(E) The maximum kinetic energy occurs at maximum displacement of the mass from its equilibrium position.

__E__ 3) When a mass is attached to a spring, the period of oscillation is approximately 2.0 seconds. When the mass attached to the spring is doubled, the period of oscillation is most nearly

(A) 0.5 s
(B) 1.0 s
(C) 1.4 s
(D) 2.0 s
(E) 2.8 s

$\sqrt{2}\,T_s = 2\pi\sqrt{2m/k}$

__E__ 4) An ideal spring obeys Hooke's law, F = - kx. A mass of 0.50 kilogram hung vertically from this spring stretches the spring 0.075 meter. The value or the force constant for the spring is most nearly

(A) 0.33 N/m
(B) 0.66 N/m
(C) 6.6 N/m
(D) 33 N/m
(E) 66 N/m

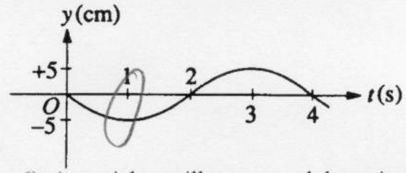
$F = kx$

$\frac{mg}{x} = k$

$\frac{.5(10)}{.075} =$

______ 5) When an object oscillating in simp1e harmonic motion is at its maximum displacement from the equi1ibrium position, which of the following is true of the values of its speed and the magnitude of the restoring force?

Speed	Restoring Force
(A) Zero	Maximum
(B) Zero	Zero
(C) ½ maximum	½ maximum
(D) Maximum	½ maximum
(E) Maximum	Zero



__A__ 6) A particle oscillates up and down in simple harmonic motion. Its height y as a function of time t is shown in the diagram above. At what time t does the particle achieve its maximum positive acceleration?

(A) 1s
(B) 2s
(C) 3s
(D) 4s
(E) None of the above, because the acceleration is constant

__D__ 7) A block of mass m slides on a horizontal frictionless table with an initial speed v_0. It then compresses a spring of force constant k and is brought to rest. How much is the spring compressed from its natural length?

(A) $\frac{v_0^2}{2g}$

(B) $\frac{mg}{k}$

(C) $\frac{m}{k}v_0$

(D) $\sqrt{\frac{m}{k}}v_0$

(E) $\sqrt{\frac{k}{m}}v_0$

$E_1 = E_2$

$\frac{1}{2}mv^2 = \frac{1}{2}kx^2$

$x = \sqrt{\frac{m}{k}}\,v$

__A__ 8) Sound in air can best be described as which of the following types of waves?

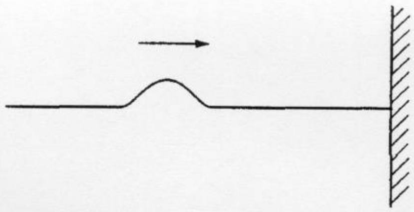
(A) Longitudinal
(B) Transverse
(C) Torsional
(D) Electromagnetic
(E) Polarized

__E__ 9) A radar operates at a wavelength of 3 centimeters. The frequency of these waves is

(A) 10^{-10} Hz
(B) 10^{6} Hz
(C) 10^{8} Hz
(D) 3×10^{8} Hz
(E) 10^{10} Hz

$c = f\lambda$

$\frac{3E8}{.03\,m} = f$



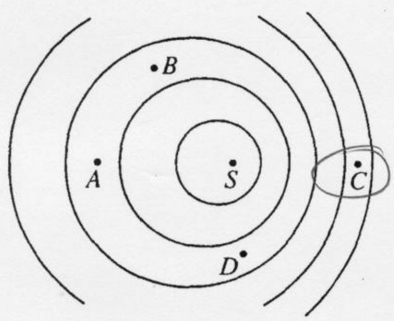
B ______10) One end of a horizontal string is fixed to a wall. A transverse wave pulse is generated at the other end, moves toward the wall as shown above, and is reflected at the wall. Properties of the reflected pulse include which of the following?

I. It has a greater speed than that of the incident pulse.

II. It has a greater amplitude than that of the incident pulse.

III. It is on the opposite side of the string from the incident pulse.

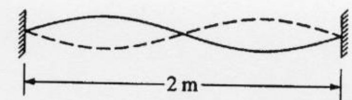
(A) I only
(B) III only
(C) I and II only
(D) II and III only
(E) I, II, and III



C ______11) A small vibrating object on the surface of a ripple tank is the source of waves of frequency 20 Hz and speed 60 cm/s. If the source S is moving to the right, as shown above, with speed 20 cm/s, at which of the labeled points will the frequency measured by a stationary observer be greatest?

(A) A
(B) B
(C) C
(D) D
(E) It will be the same at all four points.

Questions 27-28



n = 2

A standing wave of frequency 5 hertz is set up on a string 2 meters long with nodes at both ends and in the center, as shown above.

D ______27. The speed at which waves propagate on the string is

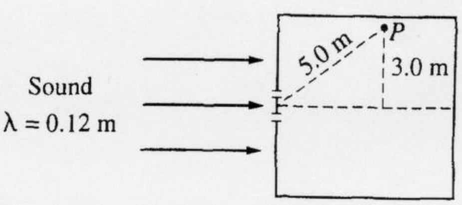
(A) 0.4 m/s
(B) 2.5 m/s
(C) 5 m/s
(D) 10 m/s
(E) 20 m/s

$\lambda = 2\text{ m}$
$f = 5\text{ Hz}$

B ______28. The fundamental frequency of vibration of the string is

(A) I Hz
(B) 2.5 Hz
(C) 5 Hz
(D) 7.5 Hz
(E) 10 Hz

$f_2 = nf_1$
$5\text{ Hz} = 2f_1$



D ______14) Plane sound waves of wavelength 0.12 m are incident on two narrow slits in a box with nonreflecting walls, as shown above. At a distance of 5.0 m from the center of the slits, a first-order maximum occurs at point P, which is 3.0 m from the central maximum. The distance between the slits is most nearly

(A) 0.07 m
(B) 0.09 m
(C) 0.16 m
(D) 0.20 m
(E) 0.24 m

Cant use !

$x_m \approx \frac{m\lambda L}{d}$

$d \sin\theta = m\lambda$

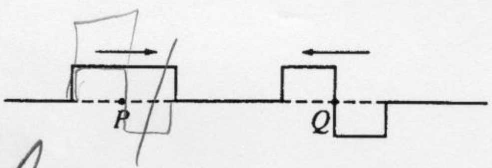
$d \frac{3}{5} = 1(0.12)$

$d =$

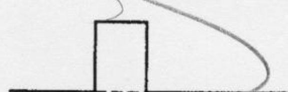
C ______15) In the Doppler effect for sound waves, factors that affect the frequency that the observer hears include which of the following?

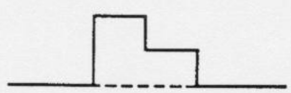
I. The speed of the source
II. The speed of the observer
III. The loudness of the sound

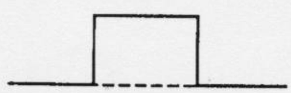
(A) I only
(B) III only
(C) I and II only
(D) II and III only
(E) I, II, and III

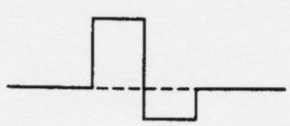


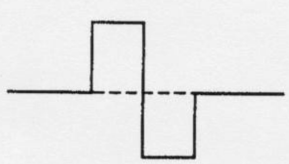
A ______16) The figure above shows two wave pulses that are approaching each other. Which of the following best shows the shape of the resultant pulse when the centers of the pulses, points P and Q. coincide?

(A) 

(B) 

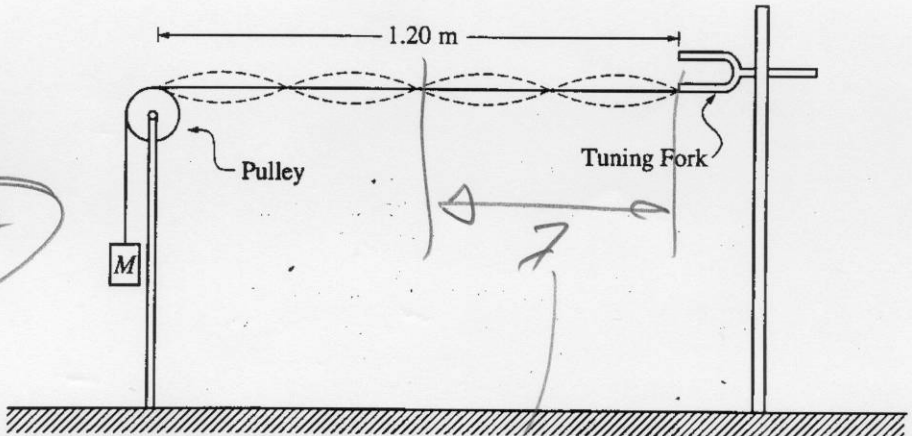
(C) 

(D) 

(E) 

1998 PHYSICS B5 (10 points)

Units = 1pt



To demonstrate standing waves, one end of a string is attached to a tuning fork with frequency 120 Hz. The other end of the string passes over a pulley and is connected to a suspended mass *M* as shown in the figure above. The value of M is such that the standing wave pattern has four "loops." The length of the string from the tuning fork to the point where the string touches the top of the pulley is 1.20 m. The linear density of the string is 1.0×10^{-4} kg/m, and remains constant throughout the experiment.

(2) (a) Determine the wavelength of the standing wave.

1 $\lambda = \frac{1}{2} L$ = 1 $\boxed{0.6\ m}$

(2) (b) Determine the speed of transverse waves along the string.

1 $v = f\lambda$ = 120 Hz (0.6 m) = 1 $\boxed{72\ m/s}$

(3) (c) The speed of waves along the string increases with increasing tension in the string. Indicate whether the value of *M* should be increased or decreased in order to double the number of loops in the standing wave pattern. Justify your answer.

doubling the # of loops = decreasing λ 1

1 ↓$v = f\lambda$↓ (f same) so... we need to decrease velocity which means

1 $\boxed{\text{decreasing the mass } M}$

(2) (d) If a point on the string at an antinode moves a total vertical distance of 4 cm during one complete cycle, what is the amplitude of the standing wave?

up and back = 4 cm

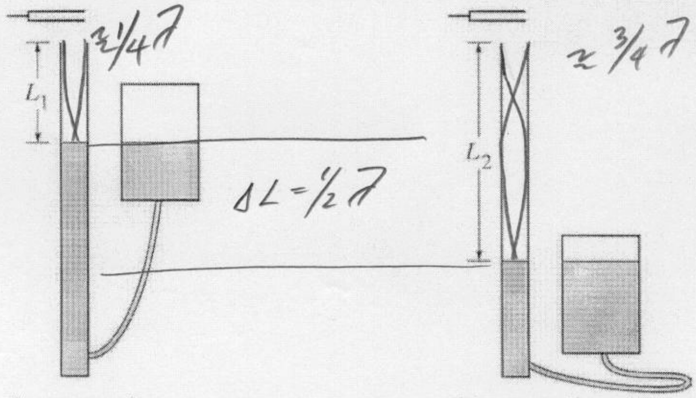
that means ↕ = 2 cm

which means the amplitude = 2 $\boxed{1\ cm}$

1pt is awarded for the answer of 2 cm

(This problem has been modified and is only worth 12 points)

2004 AP® PHYSICS B FREE-RESPONSE QUESTIONS (Form B)



Resonance 1 Resonance 2

Note: Figure not drawn to scale.

3. (15 points)

A vibrating tuning fork is held above a column of air, as shown in the diagrams above. The reservoir is raised and lowered to change the water level, and thus the length of the column of air. The shortest length of air column that produces a resonance is $L_1 = 0.25$ m, and the next resonance is heard when the air column is $L_2 = 0.80$ m long. The speed of sound in air at 20°C is 343 m/s and the speed of sound in water is 1490 m/s.

(4) (a) Calculate the wavelength of the standing sound wave produced by this tuning fork.

$\Delta L = \frac{1}{2}\lambda = 0.8 - 0.25 = 0.55$ ← 3pts

$\boxed{\lambda = 1.1\text{ m}}$ ← 1pt

Max 3pts if they only used one tube to calculate the λ!

(2) (b) Calculate the frequency of the tuning fork that produces the standing wave, assuming the air is at 20°C.

1 $v = f\lambda$

$f = v/\lambda = \frac{343\text{ m/s}}{1.1\text{ m}} = \boxed{312\text{ Hz}}$ 1

(3) (d) The water level is lowered again until a third resonance is heard. Calculate the length L_3 of the air column that produces this third resonance.

1 (3rd Harmonic occurs at $5/4\,\lambda$) (which is $1/2\,\lambda$ longer than L_2) 1

$L_2 + \frac{1}{2}\lambda = 0.8 + \frac{1.1}{2} = \boxed{1.35\text{ m}}$ 1

[only 2pts if they just multiply $5/4 \times \lambda$]

(3) (e) The student performing this experiment determines that the temperature of the room is actually slightly higher than 20°C. Is the calculation of the frequency in part (b) too high, too low, or still correct?

____ Too high 2 __✓__ Too low ____ Still correct

Justify your answer.

1 Our Temp was too low thus V_{sound} was too low in our calculations ∴ $\downarrow V = \downarrow f\lambda$ our f calculation was too low

4. (15 points)

Your teacher gives you two speakers that are in phase and are emitting the same frequency of sound, which is between 5000 and 10,000 Hz. She asks you to determine this frequency more precisely. She does not have a frequency or wavelength meter in the lab, so she asks you to design an interference experiment to determine the frequency. The speed of sound is 340 m/s at the temperature of the lab room.

(2) (a) From the list below, select the additional equipment you will need to do your experiment by checking the line next to each item.

Must use all equipment checked in parts b & c D

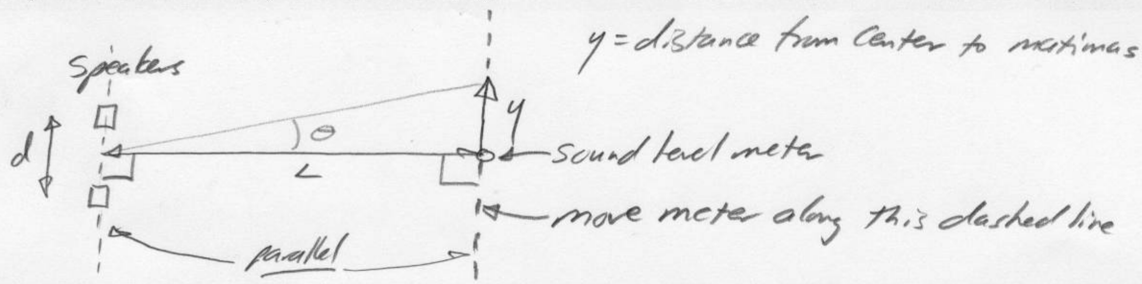
___ Speaker stand   ___ Meterstick   ___ Ruler   ___Tape measure

___ Stopwatch   ___ Sound-level meter

(b) Draw a labeled diagram of the experimental setup that you would use. On the diagram, use symbols to identify what measurements you will need to make.

(4)

1 Drawing
1 Labeling
1 Measurements
1 Symbols



(4) (c) Briefly outline the procedure that you would use to make the needed measurements, including how you would use each piece of equipment you checked in (a).

2 Description of set up
1 How to measure maxima or minima pattern
1 what measurements to make

Ex) Set speakers "d" apart,
walk a distance "L" away perpendicular to the speakers,
walk parallel to the speakers with sound level meter to find location "y" of maximas

(4) (d) Using equations, show explicitly how you would use your measurements to calculate the frequency of the sound produced by the speakers.

1 $m\lambda = d\sin\theta$ - or - $y \approx \frac{m\lambda L}{d}$

1 $\sin\theta = \frac{y}{\sqrt{y^2+L^2}}$

1 $\lambda = \frac{dy}{m\sqrt{y^2+L^2}}$ - or - $\lambda = \frac{dy}{mL}$

1 $v = f\lambda$ or $f = v/\lambda$

1 (e) If the frequency is decreased, describe how this would affect your measurements.

$f\downarrow \ \lambda\uparrow$
$\uparrow y \approx \frac{m\lambda L}{d}$

1 it would increase the distance between maximas

ELECTRICITY (Electrostatics, Circuits)

The following questions should be answered w/out a calculator or formula chart.

Electrostatics

A Electron and proton

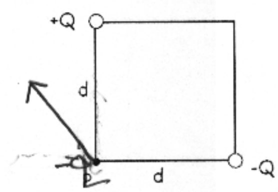
1. [redacted] in space are simultaneously released from rest. Assume that no other particles will interact with the charges. At a later time when the particles are still in the field, the electron and proton will have the same…

(+) $\vec{F_e}$ → ← $\vec{F_e}$ (−)

Electrostatic Force

(a will differ due to mass, V will differ due to a)

2. The given figure shows two charged particles, one of charge positive Q and the other of charge -Q, that are located at the opposite corners of a square with sides of length d. Draw the direction of the net electric force on a negative charge (-q) at point P?



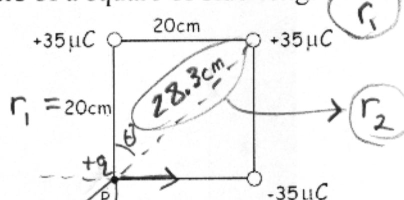
$F=\frac{kQq}{d^2}$ For the same diagram, what is the magnitude of the electric Force on the charge at point P? (in terms of q, Q, k, and d)

$F=\frac{kQq}{d^2}$

$$\Sigma F=\sqrt{2}\frac{kQq}{d^2}$$

3. Three charges, all of magnitude 35μC (Q), are placed at three corners of a square of side-length 20cm (r_1), as shown in the diagram.

$\theta = 45°$



Must split on x and y

$F=\frac{kQq}{r_2^2}$ θ P $F=\frac{kQq}{r_1^2}$ $F=\frac{kQq}{r_1^2}$

Calculate the net electric force on a charge of (+12μC) at point P in the diagram.

$F_x=\frac{kQq}{r_2^2}\cos\theta$

$$\Sigma F_x = \frac{kQq}{r_1^2} - \frac{kQq}{r_2^2}\cos\theta = 94.5 - 33.4 = 61.1N$$

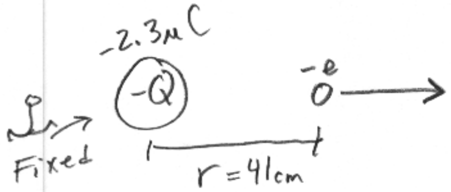
$$\Sigma F = \sqrt{\Sigma F_x^2 + \Sigma F_y^2} = 141.7N$$

$F_y=\frac{kQq}{r_2^2}\sin\theta$

$$\Sigma F_y = \frac{kQq}{r_1^2} + \frac{kQq}{r_2^2}\sin\theta = 94.5 + 33.4 = 127.9N$$

4. An electron starts from rest 41cm from a fixed point charge with Q= -2.3μC . How fast will the electron be moving when it is very far away? ∞

COE



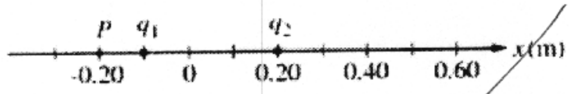
e - fundemental unit of charge $1.6\times10^{-19}C$

m_e - mass of electron $9.11\times10^{-31}Kg$

$U_E = K$ (when its ∞ away U_e is gone)

$$\frac{Kq_1q_2}{r} = \frac{1}{2}mv^2$$

$$V=\sqrt{\frac{2kQe}{m_e r}} = \sqrt{\frac{2(9\times10^9)(2.3\times10^{-6})(1.6\times10^{-19})}{(9.11\times10^{-31})(.41)}} = 1.33\times10^8 m/s$$



2006 B3 (15 points)

Two point charges, q_1 and q_2, are placed 0.30 m apart on the x-axis, as shown in the figure above. Charge q_1 has a value of -3.0×10^{-9} C. [redacted].

(a) What is the sign of charge q_2?

_____ Positive   _____ Negative

Justify your answer.

Skip

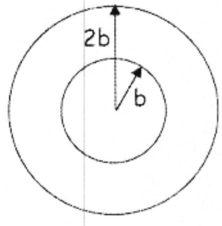
(b) Calculate the magnitude of charge q_2.

(c) Calculate the magnitude of the electric force on q_2 and indicate its direction.

(d) Determine the x-coordinate of the point on the line <u>between</u> the two charges at which the electric potential is zero.

(e) How much work must be done by an external force to bring an electron from infinity to the point at which the electric potential is zero? Explain your reasoning.

CIRCUITS

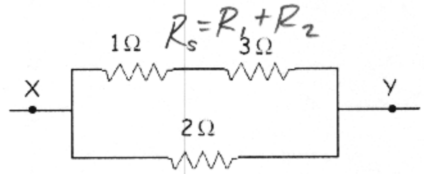


1. Two concentric circular loops of radii b and 2b, made of the same type of wire, lie in the plane of the page, as shown above. If the total resistance of the b-radius loop is R, what is the resistance ~~of the 2b-radius~~ loop?

$R = \frac{\rho l}{A} = \frac{\rho l}{\pi r^2} = \frac{\rho l}{\pi (2r)^2} = \frac{\rho l}{4\pi r^2}$ $\boxed{\frac{1}{4}R}$

2. Three resistors are connected as shown in the diagram. What is the electrical resistance of the part of the circuit shown?

$R_s = R_1 + R_2$



4Ω 2Ω $\frac{1}{R_p} = \frac{1}{4} + \frac{1}{2} = \frac{3}{4}$ $\boxed{R_p = \frac{4}{3}\Omega}$

3. A current of 2A passes through a 50Ω resistor. This resistor must be connected ~~to an emf source~~ of…

$I = \frac{V}{R}$ $V = IR = 2A \cdot 50\Omega = \boxed{100V}$

4. A wire of length L and radius r has a resistance R. What is the resistance of a second wire made from the same material that has length L/2 and radius r/2?

$R = \frac{\rho l}{A} = \frac{\rho \frac{l}{2}}{\pi (\frac{r}{2})^2} = \frac{\frac{1}{2}}{\frac{1}{4}} = \boxed{2R}$

5. A current of 15 A exists in a wire. How many seconds does it take for ~~8.0x1020~~ 8×10^{20} electrons to flow through a given cross section of the wire?

$Q = 8\times10^{20}(e) = 128C$ $I = \frac{\Delta Q}{\Delta t}$ $\Delta t = \frac{\Delta Q}{I} = \frac{128C}{15A} = \boxed{8.53s}$

fundemental unit of charge. $1.6\times10^{-19}C$

6. How much resistance is present in a 240V generator dissipating 120kW of power? How much energy is dissipated by this resistor in 10 minutes?

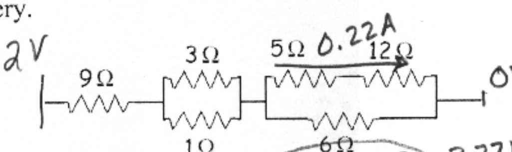
$P = IV = I^2R = \frac{V^2}{R}$ $R = \frac{V^2}{P} = \frac{(240)^2}{120\times10^3 W} = \boxed{0.48\Omega}$

$E = P \cdot t = 120\times10^3 W \cdot (10 \cdot 60)$ $\boxed{E = 7.2\times10^7 J}$

7. A certain circuit has been assembled incorrectly, because a 250Ω resistor was soldered in the location where a 100Ω resistor was meant to be. How can the circuit be fixed without changing the resistor?

Add resistors in parallel to lower the total resistance

8. Use the rules for resistors connected in parallel and series to calculate the current through the 5Ω resistor in the figure, when the complex circuit is attached to a 12V battery.



$I_0 = \frac{V}{R} = \frac{12V}{14.18\Omega} = 0.85A$

I_0 9Ω 0.75Ω I_2 17Ω 3.77V $I = \frac{V}{R}$ I_3 6Ω

I_0 9Ω 0.75Ω 4.43Ω $V = I_0 R = 3.77V$

$I_2 = 0.22A$ → through the 5 Ω resistor

$R_{eq} = 14.18\Omega$