Student	8
Average	38.3 /100
Best	72.5 /100

12^{th}G Physics (2017– 18)

3^{rd} Q Exam

(March 22, 2018)

Class	No.	Name Solutions

In a calculation problem, describe equations clearly and systematically enough to show how to solve the problem. If not enough, you won't get any point.

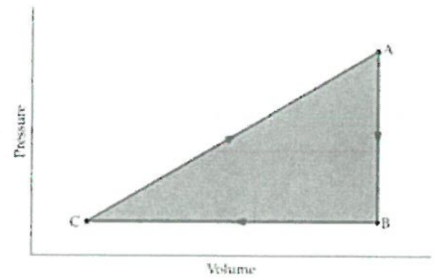
5point/question x 21questions=105points
Max 100 points

Exam	／[Total 100 点]

Lab Reports	Number of Full Reports		Score	

Gravitational acceleration rate	$g = 9.80$ m/s^2
Atmospheric Pressure	1.00 atm = 1.013×10^5 Pa
Avogadro's Number	$N_A = 6.022 \times 10^{23}$ molecule / mol
Universal Gas Constant	$R = 8.31$ J/(mol・K)
Boltzmann Constant	$k = 1.38 \times 10^{-23}$ J/K
Elementary Charge	$e = 1.60 \times 10^{-19}$ C
Electron Mass	$m_e = 9.11 \times 10^{-31}$ kg
Proton Mass	$m_p = 1.673 \times 10^{-27}$ kg
Coulomb's Law Constant	$k = 8.99 \times 10^9$ N・m^2/C^2
Permittivity of Free Space	$\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/(N・m^2)
Universal Gravitational Constant	$G = 6.67 \times 10^{-11}$ N・m^2/kg^2
Avogadro's Number	$N_A = 6.022 \times 10^{23}$ mol^{-1}
Magnetic Permeability of Free Space	$\mu_0 = 4\pi \times 10^{-7}$ T・m/A

(1) An ideal gas is taken through the three processes shown in the figure at the right. Fid the missing entries in the following table.



	Q	W	ΔU
A → B	(1-a)	(1-b)	-38 J
B → C	(1-c)	-89 J	-82 J
C → A	332 J	(1-d)	(1-e)

(Equations)

(a, b) Constant V → $W = 0$

$\Delta U = Q - W = Q = -38\ (J)$

(c) $\Delta U = Q - W \rightarrow Q = \Delta U + W = -82 + (-89) = -171$

(d, e) $\Delta U_{AB} + \Delta U_{BC} + \Delta U_{CA} = 0$

$\therefore \Delta U_{CA} = -(\Delta U_{AB} + \Delta U_{BC}) = 38 + 82 = 120$

$W = Q - \Delta U$

$= 332 - 120 = 212$

(1-a) Answer
−38 J
(1-b) Answer 0
(1-c) Answer −171 J
(1-d) Answer 212 J
(1-e) Answer 120 J

(55%)

(2) A typical dorm room or bedroom contains about 2500 moles of air. Find the change in the internal energy of this much air when it is cooled from 23.9℃ to 11.6℃ at a constant pressure of 1.00 atm.

(Equations)

$n = 2500$ moles.

Diatomic

$C_v = \frac{5}{2} R = 2.5 \times 8.31 = 20.78$

$\Delta U = n C_v \Delta T$

$= 2500 \times 20.78 \times (11.6 - 23.9)$

$= -6.393 \times 10^5\ (J)$

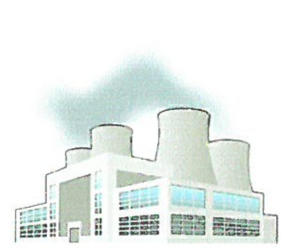
$\rightarrow -6.39 \times 10^5$ J

(2) Answer
-6.39×10^5 J

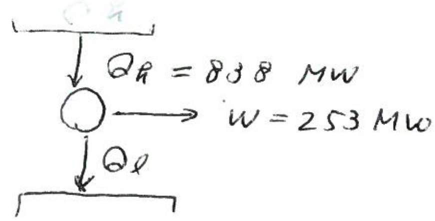
(39%)

$C_v = \frac{3}{2} R$ 2" ÷ 2

(3) A nuclear power plant has a reactor that produces heat at the rate of 838 MW. This heat is used to produce 253 MW of mechanical power to drive an electrical generator.
(3-a) How much heat is discarded to the environment by this power plant?
(2-b) What is the thermal efficiency of the plant?
(Equations)



(a) $Q_l = Q_h - W = 838 - 253 = 585$ (MW)



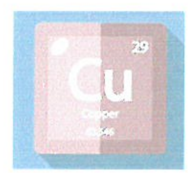
(b) $e = \frac{W}{Q_h} = \frac{253}{838} = 0.3019 \to 0.302$

(3-a) Answer
585 MW

(3-b) Answer
30.2 %

(41 %)

(4,5) A small object carrying a charge of - 55.0 μ C experiences a downward force of 6.20 x 10^{-9} N when placed at a certain point in a electric field.
(4) What are the magnitude and direction of the electric field at this point?
(5)What would be the magnitude and direction of the force acting on a copper nucleus (atomic number=29, atomic weight=63.5 g/mol) placed at the same point in the electric field?
(Equations)



(4) $E = \frac{F}{|q|} = \frac{6.20\times10^{-9}}{55\times10^{-6}} = 0.1127\times10^{-3}$

$\to 1.13\times10^{-4}$

(5) $Q = 29 \times e = 29\times1.60\times10^{-19}$ (C)

$F = QE$

$= 29\times1.60\times10^{-19}\times1.127\times10^{-4}$

$= 52.29\times10^{-23} = 5.229\times10^{-22}$

$\longrightarrow 5.23\times10^{-22}$

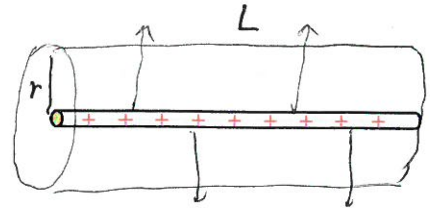
(4) Answer
1.13×10^{-4} N/C ~~upward~~

(85 %)

(5) Answer
5.23×10^{-22} N upward

(20 %)

(6) A very long, straight wire has charge per unit length 1.50 x 10^{-10} C/m. At what distance from the wire is the electric field magnitude equal to 2.50 N/C?
(Equations)



Gauss' Law $\Phi = EA = \frac{q_{encl.}}{\varepsilon_0}$

$q_{encl.} = 1.50 \times 10^{-10} (C/m) \times L$

$A = 2\pi r \cdot L$

$\therefore 2.50 \times 2\pi r \cdot L = \frac{1.50 \times 10^{-10} \cdot L}{8.85 \times 10^{-12}}$

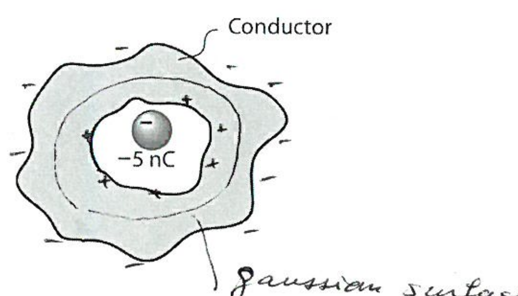
$r = \frac{1.50 \times 10^{-10}}{2\pi \times 2.50 \times 8.85 \times 10^{-12}}$

$= 0.01079 \times 10^{2} = 1.079$

$\rightarrow 1.08 (m)$

(6) Answer
1.08 m
(0)

(7) The conductor shown in cross section in the figure at the right carries a total charge of +3 nC. The charge within the cavity, insulated from the conductor, is – 5 nC. Hw much charge is on each surface (inner and outer) of the conductor?
(Equations)



(Inner)

$\Phi = \sum EA \cos\phi = \frac{q_{encl.}}{\varepsilon_0} = 0$

$(\because E = 0)$

$q_{encl.} = -5nC + Q_{inner} = 0$

$Q_{inner} = +5nC$

(Outer)

$Q_{total} = +3nC = Q_{outer} + Q_{inner}$

$Q_{outer} = +3nC - Q_{inner}$

$= +3nC - 5nC$

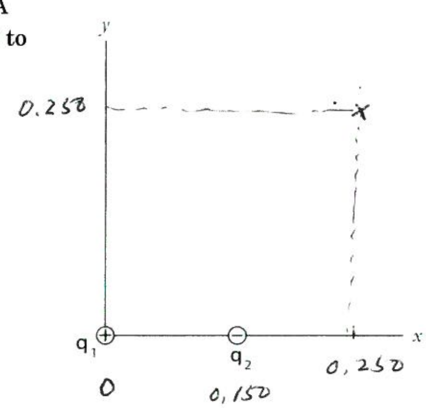
$= -2nC$

(7) Answer

inner	+5 nC
outer	−2 nC

(19%)

(8) A point charge $q_1 = +2.40\ \mu C$ is held stationary at the origin. A second point charge $q_2 = -4.30\ \mu C$ moves from the $x = 0.150$ m, $y = 0$ to the point $x = 0.250$ m, $y = 0.250$ m. How much work is done by the electric force on q_2?
(Equations)



$$U = k\frac{q_1 q_2}{r} = k\frac{2.40 \times (-4.30)}{0.150} \times 10^{-12}$$

$$U' = k\frac{q_1 q_2}{r'} = k\frac{2.40 \times (-4.30)}{0.250\sqrt{2}} \times 10^{-12}$$

$$\Delta U = U' - U = k \cdot 2.40 \times (-4.30) \times 10^{-12}\left(\frac{1}{0.250\sqrt{2}} - \frac{1}{0.150}\right)$$

$(k = 8.99 \times 10^{9})$

$$= -92.777 \times 10^{-3} \times (-3.8382)$$

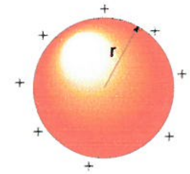
$$= 356.10 \times 10^{-3} = 0.3561\ (J) \rightarrow 0.356\ (J)$$

$$W = -\Delta U = -0.356\ J$$

(8) Answer
-0.356 J

(○)

(9) A total electric charge of 3.50 nC is distributed uniformly over the surface of a metal sohere with a radius of 24.0 cm. Assuming that the potential is zero at a point at infinity, find the value of the potential at the following distances from the center of the sphere:
(9-a) 48.0 cm
(9-b) 24.0 cm
(9-c) 12.0 cm
(Equations)



(a) $V = k\frac{q}{r}$

$= 8.99\times 10^{9} \times \frac{3.50\times 10^{-9}}{0.480} = 65.55 \longrightarrow 65.6$ (V)

(b) $V = 8.99\times 10^{9} \times \frac{3.50\times 10^{-9}}{0.240} = 131.1 \longrightarrow 131$ (V)

(c) $V = 0$

(9-a) Answer
65.6 V
(9-b) Answer
131 V
(9-c) Answer
0

(26%)

(10,11) As a crude model for lightning, consider the ground to be one plate of a parallel-plate capacitor and a cloud at an altitude of 550 m to be the other plate. Assume the surface are of the cloud to be the same as the area of a square that is 0.50 km on a side.
(10) What is the capacitance of this capacitor?
(11) How much charge can the cloud hold before a spark results assuming that dielectric breakdown occurs if the electric field in air exceed 3.0 x 10^6 V/m.
(Equations)

(10) $C = \varepsilon_0 \frac{A}{d}$, $d = 550\ m$

$A = 500 \times 500 = 250000\ m^2$

$C = 8.85 \times 10^{-12} \times \frac{250000}{550} = 4023 \times 10^{-12}$

$= 4.023 \times 10^{-9}$

$\rightarrow 4.0 \times 10^{-9}\ (F)$

(11) $E_b = 3.0 \times 10^6\ V/m$

$V = E_b d = 3.0 \times 10^6 \times 550$

$= 1650 \times 10^6\ (V)$

$Q = CV$

$= 4.023 \times 10^{-9} \times 1650 \times 10^6$

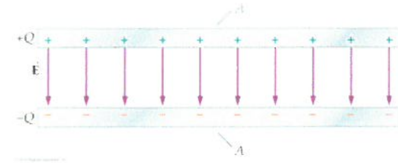
$= 6.638 \longrightarrow 6.6$

(10) Answer

4.0 nF (46%)

(11) Answer

6.6 C (38%)



(12~14) A parallel-plate capacitor has plates with an area of A=0.036 m^2 and a separation of d=0.75 mm. The magnitude of electric field E=2.88 x 10^7 N/C.

(12-a) Find the charge on the capacitor plates.
(12-b) Find the potential difference between the plates.

(13-a) Find the capacitance of the capacitor.
(13-b) A particle with a mass of 3.8 g and a charge of + 4.56 x 10^{-6} C is released from rest at the positive plate and moves to the negative plate. Find the change in electric potential energy for this charge.

(14) Find the speed of the particle when it reaches the negative plate.

(12) $\Phi = EA = \frac{Q}{\varepsilon_0} \rightarrow Q = \varepsilon_0 EA = 8.85\times10^{-12} \times 2.88\times10^{7} \times 0.036$

$= 9.176\times10^{-6} \rightarrow 9.2\ \mu C$

$V = Ed = 2.88\times10^{7} \times 0.75\times10^{-3}$

$= 2.16\times10^{4} \longrightarrow 2.2\times10^{4}\ V$

(13) $C = \frac{Q}{V} = \frac{9.176\times10^{-6}}{2.16\times10^{4}} = 4.248\times10^{-10} \longrightarrow 4.2\times10^{-10}\ F$

$U = qEd$

$= 4.56\times10^{-6} \times 2.88\times10^{7} \times 0.75\times10^{-3}$

$= 9.8496\times10^{-2} \longrightarrow 9.8\times10^{-2}\ J$

change of U must be negative

(14) $U = K = \frac{1}{2}mv^2$

$v = \sqrt{\frac{2\times9.8496\times10^{-2}}{3.8\times10^{-3}}} = 7.20$

$\rightarrow 7.2$

(12-a) Answer	$9.2\ \mu C$
(12-b) Answer	$2.2\times10^{4}\ V$

(43%)

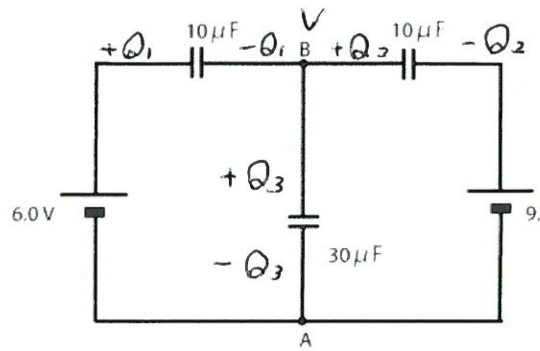
(13-a) Answer	$4.2\times10^{-10}\ F$
(13-b) Answer	$-9.8\times10^{-2}\ J$

(40 %)

(14) Answer	7.2 m/s

(25 %)

(15) Find the potential at the point B in the following circuit including two batteries and three capacitors, assuming that the potential at the point A is 0V. The capacitors were not charged before connection. (Equations)



$Q_3 - Q_1 - Q_2 = 0$ — ①

$Q_1 = 10\times10^{-6}(6 - V)$ — ②

$Q_2 = 10\times10^{-6}(9 - V)$ — ③

$Q_3 = 30\times10^{-6}\times V$ — ④

① ~ ④

$30\times10^{-6}V - 10\times10^{-6}(6-V) - 10\times10^{-6}(9-V) = 0$

$30V - 60 + 10V - 90 + 10V = 0$

$50V = 150$

$V = 3.0$

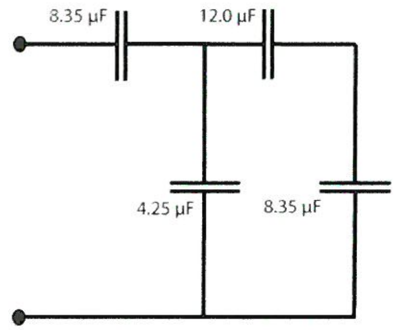
(15) Answer

3.0 V

(50 %)

(16) Find the equivalent capacitance.

(Equations)



$$\frac{1}{C_1} = \frac{1}{12.0} + \frac{1}{8.35}$$

$$C_1 = 4.924$$

$$C_2 = 4.924 + 4.25$$

$$= 9.174$$

$$\frac{1}{C_3} = \frac{1}{9.174} + \frac{1}{8.35}$$

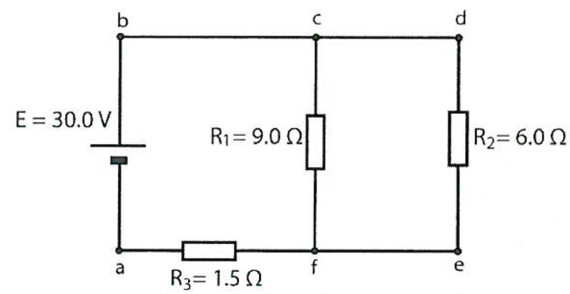
$$C_3 = 4.371 \longrightarrow 4.37$$

(16) Answer

4.37 μF

(69%)

(17) Find the followings:
(17-a) The current through the 6.0 Ω resistor R_2.
(17-b) Find the power consumed in the 1.5 Ω resistor R_3 when the two points, c and e, are short-circuited.
(Equations)



(a) $\frac{1}{R'} = \frac{1}{9.0} + \frac{1}{6.0}$

$R' = 3.600$

$R = 3.600 + 1.5 = 5.10$

$I = \frac{E}{R} = \frac{30.0}{5.10} = 5.88\ (A)$

$V_3 = IR_3 = 5.88 \times 1.5 = 8.82\ (V)$

$V_2 = 30 - 8.82 = 21.18\ (V)$

$I_2 = \frac{V_2}{R_2} = \frac{21.18}{6.0} = 3.53 \longrightarrow 3.5\ (A)$

(b) $R = 1.5\ (\Omega)$

$I_3 = \frac{E}{R} = \frac{30}{1.5} = 20.0\ (A)$

$P_3 = I_3^2 R_3$

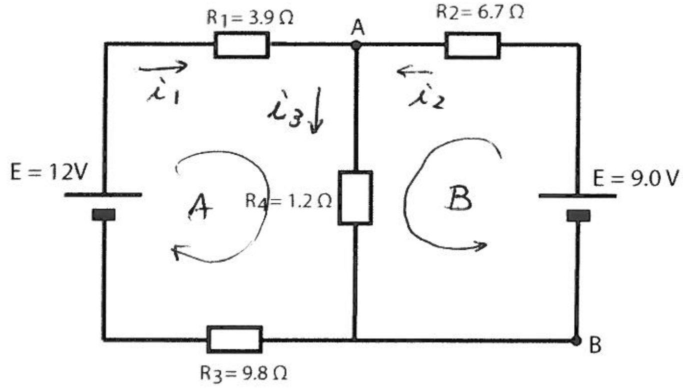
$= 20.0^2 \times 1.5$

$= 600 \longrightarrow 600W$

(17-a) Answer	3.5 A
(17-b) Answer	600 W

(58%)

(18) Find the current and its direction in each resistor in the figure. Determine the potential difference between the points A and B.
(Equations)



$i_1 + i_2 = i_3$ —①

A: $12 = (3.9 + 9.8)\,i_1 + 1.2\,i_3$ $\quad 12 = 13.7\,i_1 + 1.2\,i_3$ —②

B: $9 = 6.7\,i_2 + 1.2\,i_3$ —③

① + ② $\quad 12 = 13.7\,i_1 + 1.2\,i_1 + 1.2\,i_2 \quad 12 = 14.9\,i_1 + 1.2\,i_2$ —②′

① + ③ $\quad 9 = 6.7\,i_2 + 1.2\,i_1 + 1.2\,i_2 \quad 9 = 1.2\,i_1 + 7.9\,i_2$ —③′

②′ × 1.2 $\quad 14.4 = 17.88\,i_1 + 1.44\,i_2$

③′ × 14.9 $\quad 134.1 = 17.88\,i_1 + 117.71\,i_2$

$119.7 = \quad + 116.27\,i_2 \rightarrow i_2 = 1.030 \rightarrow 1.0\ A$

$$i_1 = \frac{14.4 - 1.44 \times 1.030}{17.88} = 0.722 \longrightarrow 0.72\ A$$

$i_3 = i_1 + i_2 = 0.722 + 1.030$

$= 1.752 \longrightarrow 1.8\ A$

$V_2 = i_2 R_2 = 1.030 \times 6.7 = 6.90$

$V_4 = 9.0 - 6.90 = 2.10$

$\longrightarrow 2.1\ (V)$

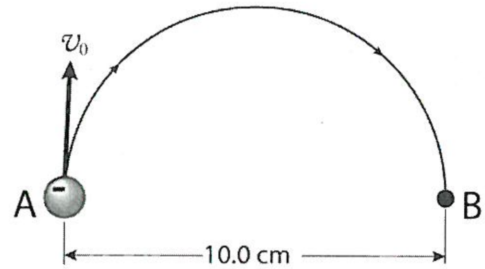
(18) Answer R1	0.72 A right
(18) Answer R2	1.0 A left
(18) Answer R3	0.72 A left
(18) Answer R4	1.8 A down
(18) Answer Potential Difference	2.1 V

(43')

(19) An electron at point A in the figure at the right has a speed of v0 of 1.41 x 10~~6~~ m/s.

(19-a) Find the magnitude and direction of the magnetic flux density tha will cause the electron to follow the semicircular path from A to B.

(19-b) Find the time required for the electron to move from A to B.



(Equations)

(a) $m_e \frac{v^2}{r} = e v B$

$$B = \frac{m_e v}{e r} = \frac{9.11 \times 10^{-31} \times 1.41 \times 10^{6}}{1.60 \times 10^{-19} \times 0.0500}$$

$$= 160.6 \times 10^{-31+6+19} = 160.6 \times 10^{-6}$$

$$\rightarrow 1.61 \times 10^{-4}\ (T)$$

(b) $t = \frac{L}{v}$

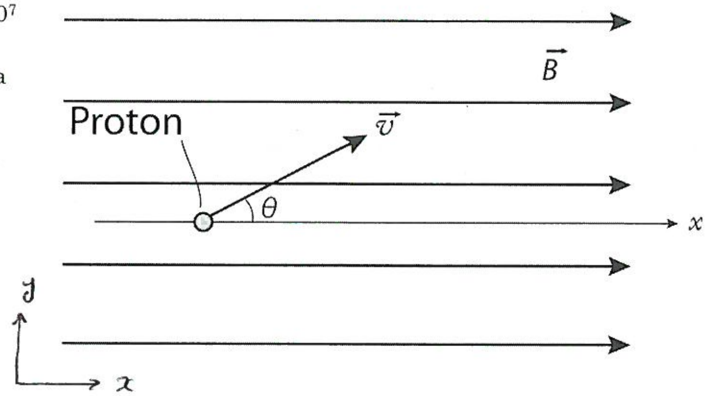
$$= \frac{2\pi \times 0.0500 \times \frac{1}{2}}{1.41 \times 10^{6}} = 0.1114 \times 10^{-6}$$

$$\rightarrow 1.11 \times 10^{-7}\ (s)$$

(19-a) Answer 1.61×10^{-4} T into the page
(19-b) Answer 1.11×10^{-7} s

(20%)

(20) A proton has the initial velocity of $v_0 = 1.42 \times 10^7$ m/s and at an angle of 65.0° to the magnetic field with a magnetic flux density of 1.00 T. It performs a helical motion.
(20-a) Find the period of the helical motion.
(20-b) Find the distance it travels to the direction of the magnetic field during one period.
(Equations)



(a) $v_y = 1.42 \times 10^7 \sin 65.0°$

$m \frac{v_y^2}{r} = q v_y B \rightarrow \frac{m}{qB} = \frac{r}{v_y}$ —①

$T = \frac{2\pi r}{v_y} \underset{①}{=} \frac{2\pi m}{qB} = \frac{2\pi \times 1.673 \times 10^{-27}}{1.60 \times 10^{-19} \times 1.00}$

$= 6.571 \times 10^{-27+19} = 6.571 \times 10^{-8} \rightarrow 6.57 \times 10^{-8}$ (s)

(b)

$x = v_x T$

$= v \cos\theta \cdot T$

$= 1.42 \times 10^7 \cos 65.0° \times 6.571 \times 10^{-8}$

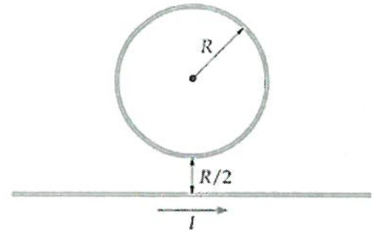
$= 3.943 \times 10^{-1}$ m

$= 39.43$ cm $\rightarrow 39.4$ cm

(20-a) Answer
6.57×10^{-8} s
(20-b) Answer
39.4 cm

(19%)

(21) A single current-carrying circular loop of radius R is placed next to a long, straight wire, as shown in the figure at the right. The current in the straight wire points to the right and is of magnitude I.



(21-a) In which direction must current flow in the loop to produce zero magnetic field at its center?

(21-b) Find the magnitude of the current in the previous problem.

(Equations)

(a)

(b)

$$H_1 = \frac{1}{2\pi}\frac{I}{r} = \frac{1}{2\pi}\frac{I}{1.5R} = \frac{I}{3\pi R}$$

$$H_2 = \frac{1}{2}\frac{I'}{r} = \frac{1}{2}\frac{I'}{R}$$

$$H_1 = H_2 \quad \frac{I}{3\pi R} = \frac{1}{2}\frac{I'}{R}$$

$$I' = \frac{2}{3\pi} I$$

(21-a) Answer	CW
(21-b) Answer	$\frac{2}{3\pi} I$

(31%)

0.212 I

Your opinions

The solution will be shown on the Website of Physic Class tomorrow night.