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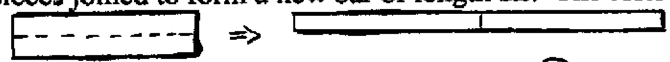
PART A

FOR EACH OF THE FOLLOWING QUESTIONS IN PART A, ENTER THE MOST APPROPRIATE RESPONSE ON THE OMR SHEET.

A1. A rectangular bar of copper of length L has a resistance of R between its ends. The bar is now cut in half lengthwise and the pieces joined to form a new bar of length $2L$. The resistance of the new bar of copper is

E



$A' = \frac{1}{2}A$

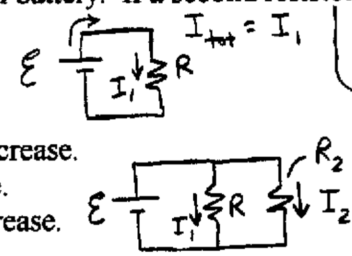
$L' = 2L$

(A) ¼ R (B) ½ R (C) R (D) 2 R (E) 4 R

A2. A simple circuit contains a resistance R and an ideal battery. If a second resistor is connected in parallel with R,

C

(A) the voltage drop across R will decrease.
(B) the current through R will decrease.
(C) the total current drawn from the battery will increase.
(D) the rate of energy dissipation in R will increase.
(E) the equivalent resistance of the circuit will increase.



$I_{tot} = I_1$

$I'_{tot} = I_1 + I_2$

$R' = \frac{\rho L'}{A'} = \frac{\rho(2L)}{\frac{1}{2}A}$

$R' = \frac{4\rho L}{A} = 4R$

A3. Which one of the following statements is correct? The kW·h is a unit of

E

(A) power. (B) voltage. (C) current.
(D) charge. (E) energy.

$kW \cdot h = 1000 \frac{J}{s} \cdot 3600 s = 3.6 \times 10^6 J$

A4. A charged particle enters a region where there is a magnetic field that is perpendicular to the particle's velocity. The direction of the magnetic force that acts on the charged particle depends on

A

(A) the sign of the charge. (B) the magnitude of the charge.
(C) the speed of light. (D) the speed of the particle.
(E) the magnitude of the magnetic field.

$|\vec{F}| = qvB\sin\theta$

dir'n of $\vec{F}$ depends on q from RHR

A5. Consider the electromagnetic waves that comprise the various colours of visible light. When propagating in a vacuum these waves differ in

D

(A) frequency only. (B) wavelength only.
(C) speed only. (D) frequency and wavelength.
(E) frequency and speed.

$v = c = f\lambda$

↑ constant in vacuum

continued on page 3 ...

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A6. Consider a situation in which parallel light rays strike a surface and remain parallel after reflection. This is called

C

(A) total internal reflection.
(B) diffuse reflection.
(C) specular reflection.
(D) refraction.
(E) diffraction.

A7. An index of refraction less than one for a medium would imply $n = \frac{c}{v}$

C

(A) that the speed of light in the medium is less than the speed of light in a vacuum.
(B) that the speed of light in the medium is the same as the speed of light in a vacuum.
(C) that the speed of light in the medium is greater than the speed of light in a vacuum.
(D) that refraction is not possible.
(E) that all the light leaving the medium is totally internally reflected regardless of the angle.

A8. Suppose light passes from air into water, with an angle of incidence of 15°. Which of the following could be the angle of refraction? $n_{air} \sin\theta_{air} = n_{water} \sin\theta_{water}$

A

(A) 10° (B) 20° (C) 30° (D) 45° (E) 60°

Since $n_{water} > n_{air}$, $\theta_{water} < \theta_{air}$

A9. When a beam of sunlight is sent through a prism the sunlight is separated into a spectrum of colours. The spreading of light into its colour components is called

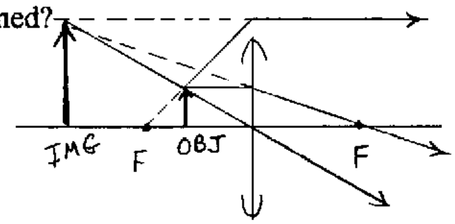
E

(A) rarefaction.
(B) reflection.
(C) magnification.
(D) divergence.
(E) dispersion.

A10. An object is placed between a converging lens and its focal point. Which one of the following correctly describes the image which is formed?

A

(A) virtual, erect, enlarged
(B) virtual, inverted, reduced
(C) real, erect, enlarged
(D) real, inverted, enlarged
(E) real, inverted, reduced



continued on page 4 ...

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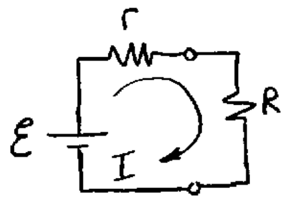
PART B

FOR EACH OF THE FOLLOWING PROBLEMS, WORK OUT THE SOLUTION IN THE SPACE PROVIDED AND ENTER YOUR ANSWERS ON PAGE 6.

ONLY THE ANSWERS WILL BE MARKED. THE SOLUTIONS WILL NOT BE MARKED.

B1. The emf of a real battery is 9.00 V. A current of 0.850 A is drawn from the battery when a 10.0 Ω resistor is connected to it. Calculate the internal resistance of the battery.



$$\mathcal{E} = Ir + IR$$

$$\frac{\mathcal{E} - IR}{I} = r$$

$$\frac{9.00\,\text{V} - (0.850\,\text{A})(10.0\,\Omega)}{0.850\,\text{A}} = r$$

$$\boxed{r = 0.588\,\Omega}$$

B2. The average power dissipated in a light bulb is 60.0 W when it is operated in a standard 120-V household circuit. Calculate the <u>**peak**</u> current through the light bulb.

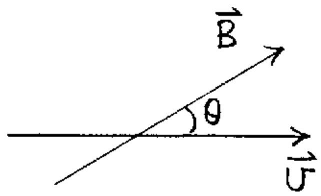
$$\bar{P} = V_{rms} I_{rms} \; ; \quad I_{rms} = \frac{I_0}{\sqrt{2}}$$

$$\bar{P} = V_{rms} \frac{I_0}{\sqrt{2}}$$

$$I_0 = \frac{\sqrt{2}\,\bar{P}}{V_{rms}} = \frac{\sqrt{2}\,(60.0\,\text{W})}{120\,\text{V}} = \boxed{0.707\,\text{A}}$$

continued on page 5 ...

B3. A charge of 2.50×10^{-5} C has a velocity of 4.50×10^{3} m/s due east as it enters a region where the magnetic field is 0.200 T directed 40.0° north of east. Calculate the magnitude of the magnetic force on the charge.

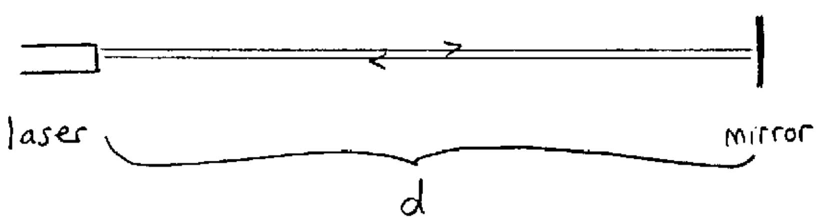


$$|\vec{F}| = qvB\sin\theta$$

$$F = (2.50\times10^{-5}\,\text{C})(4.50\times10^{3}\,\text{m/s})(0.200\,\text{T})(\sin 40.0°)$$

$$F = 1.45 \times 10^{-2}\,\text{N}$$

B4. A reflecting mirror on the surface of the Moon is 3.84×10^{8} m from the surface of the Earth. A laser on the surface of the Earth is aimed at the mirror. Calculate the elapsed time from the moment the laser is switched on to the moment the reflected laser light is observed on the Earth. Ignore any effects due to the Earth's atmosphere.



$$x = vt \Rightarrow t = \frac{x}{v} = \frac{2d}{v} = \frac{2(3.84\times10^{8}\,\text{m})}{3.00\times10^{8}\,\text{m/s}}$$

$$x = 2.56\,\text{s}$$

continued on page 6 ...

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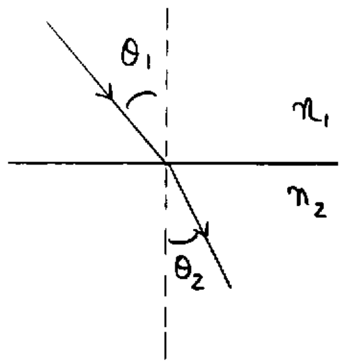
B5. Consider a light wave which passes from air into another medium. The angle of incidence is 38.0° and the angle of refraction is 23.5°. Calculate the index of refraction of the unknown medium.



$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

$$n_2 = \frac{n_1 \sin\theta_1}{\sin\theta_2}$$

$$n_2 = \frac{1.00 \sin 38.0°}{\sin 23.5°}$$

$$n_2 = 1.54$$

ANSWERS FOR PART B

ENTER THE ANSWERS FOR THE PART B PROBLEMS IN THE BOXES BELOW.

THE ANSWERS MUST CONTAIN THREE SIGNIFICANT FIGURES AND THE UNITS MUST BE GIVEN.

ONLY THE ANSWERS WILL BE MARKED. THE SOLUTIONS WILL NOT BE MARKED.

B1	0.588 Ω
B2	0.707 A
B3	1.45×10^{-2} N
B4	2.56 s
B5	1.54

continued on page 7 ...

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PART C

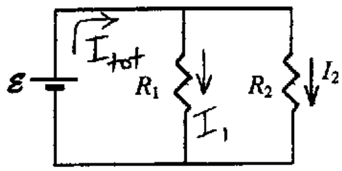
IN EACH OF THE FOLLOWING QUESTIONS, GIVE THE COMPLETE SOLUTION AND ENTER THE FINAL ANSWER IN THE BOX PROVIDED.

THE ANSWERS MUST CONTAIN THREE SIGNIFICANT FIGURES AND THE UNITS MUST BE GIVEN.

NO CREDIT WILL BE GIVEN FOR ANSWERS ONLY. EQUATIONS NOT PROVIDED ON THE FORMULA SHEET MUST BE DERIVED.

C1. Two resistors are connected in parallel across an ideal battery, as shown in the diagram. $\mathcal{E} = 5.00$ V, $R_1 = 56.2\ \Omega$, $I_2 = 0.728$ A.

(a) Calculate the total current drawn from the battery.



$I_1 = \frac{\mathcal{E}}{R_1}$

$I_{tot} = I_1 + I_2$

$I_{tot} = \frac{\mathcal{E}}{R_1} + I_2 = \frac{5.00\text{V}}{56.2\Omega} + 0.728\text{A}$

$I_{tot} = 0.817\text{A}$

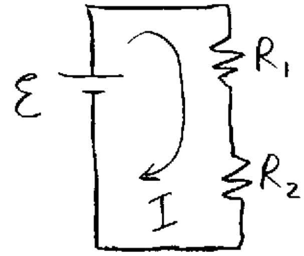
0.817A

(b) Calculate the resistance of resistor R_2.

$R_2 = \frac{\mathcal{E}}{I_2} = \frac{5.00\text{V}}{0.728\text{A}} = 6.87\Omega$

6.87Ω

(c) The two resistors are now connected in series across the same battery. Sketch the circuit diagram and calculate the new value of the total current drawn from the battery.



$I = \frac{\mathcal{E}}{R_{tot}} = \frac{\mathcal{E}}{R_1 + R_2}$

$I = \frac{5.00\text{V}}{56.2\Omega + 6.87\Omega} = 0.0793\text{ A}$

0.0793 A

continued on page 8 ...

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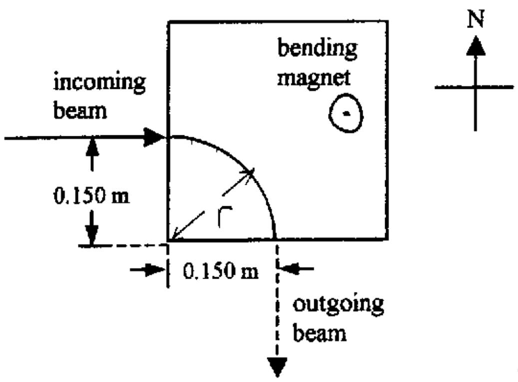
C2. Bending magnets are used to alter the direction of beams of charged particles. Suppose a beam of protons (mass 1.67×10^{-27} kg, charge $+e$) with a velocity of 1.50×10^{6} m/s is to be deflected through 90.0° as shown in the diagram. The magnetic field of the bending magnet is perpendicular to the velocity of the protons. Calculate the magnitude and direction of the required magnetic field.



magnitude:	0.104 T
direction: (circle one)	N S E W into page (out of page)

$r = 0.150\,m$

From RHR, $\vec{B}$ must be out of page

Since $\vec{B} \perp \vec{v}$, uniform circular motion occurs while the protons are in the magnetic field.

From Newton II: $\sum \vec{F} = m\vec{a}_c$

$$F_{mag} = \frac{mv^2}{r}$$

$$qvB \sin 90° = \frac{mv^2}{r}$$

$$B = \frac{mv}{qr}$$

$$B = \frac{(1.67 \times 10^{-27}\,kg)(1.50 \times 10^{6}\,m/s)}{(1.60 \times 10^{-19}\,C)(0.150\,m)} = \boxed{0.104\,T}$$

continued on page 9 ...

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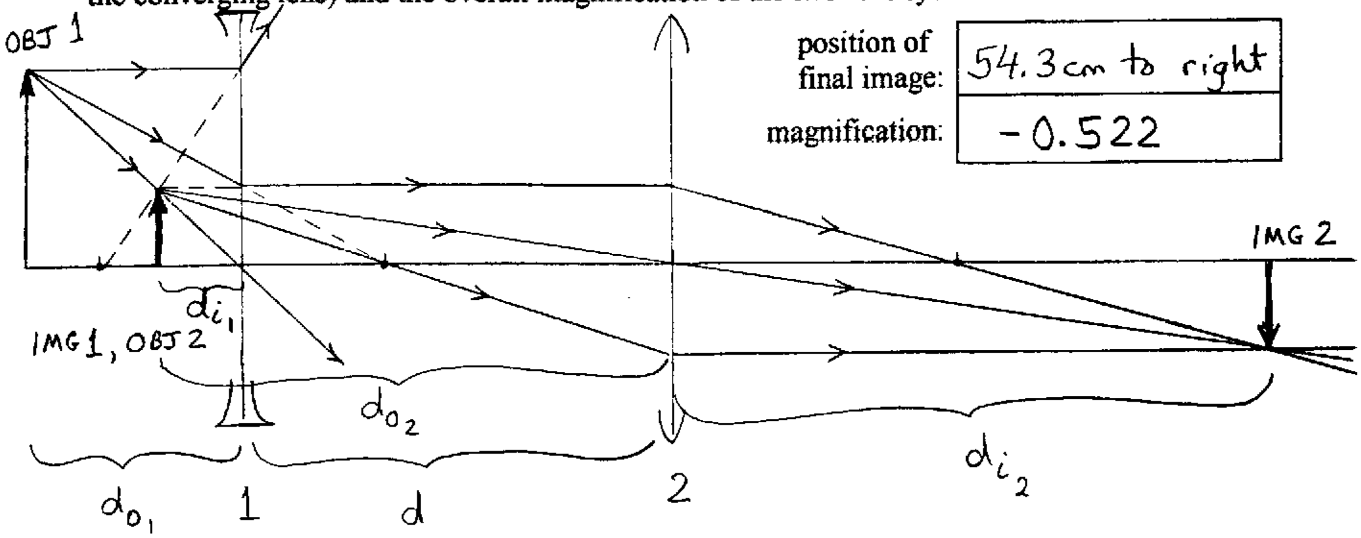
C3. Two lenses are placed 36.0 cm apart. The left lens is a diverging lens with a focal length of 12.0 cm. The right lens is a converging lens with a focal length of 24.0 cm. An object is placed 17.0 cm to the left of the diverging lens. Calculate the position of the final image (relative to the converging lens) and the overall magnification of the two-lens system.

position of final image:	54.3 cm to right
magnification:	−0.522



$$d_{i_1} = \left(\frac{1}{f_1} - \frac{1}{d_{o_1}}\right)^{-1} = \left(\frac{1}{-12.0\text{cm}} - \frac{1}{17.0\text{cm}}\right)^{-1} = -7.03\text{cm}$$

$$d_{o_2} = |d_{i_1}| + d = |-7.03\text{cm}| + 36.0\text{cm} = 43.03\text{cm}$$

$$d_{i_2} = \left(\frac{1}{f_2} - \frac{1}{d_{o_2}}\right)^{-1} = \left(\frac{1}{24.0\text{cm}} - \frac{1}{43.03\text{cm}}\right)^{-1} = \boxed{54.3\text{cm}}$$

$$m_{tot} = m_1 m_2 = \left(-\frac{d_{i_1}}{d_{o_1}}\right)\left(-\frac{d_{i_2}}{d_{o_2}}\right)$$

$$m_{tot} = \left(-\frac{(-7.03\text{cm})}{17.0\text{cm}}\right)\left(-\frac{54.3\text{cm}}{43.03\text{cm}}\right) = \boxed{-0.522}$$

END OF EXAMINATION