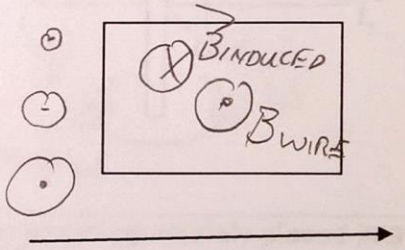
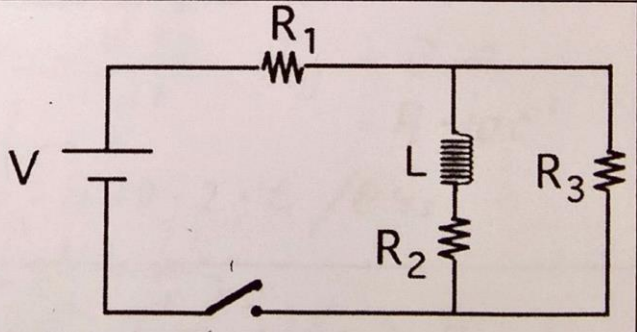
YOUR NAME
Sol A B

⊗⊙↖↗↙↘←→↑↓⊙⊗

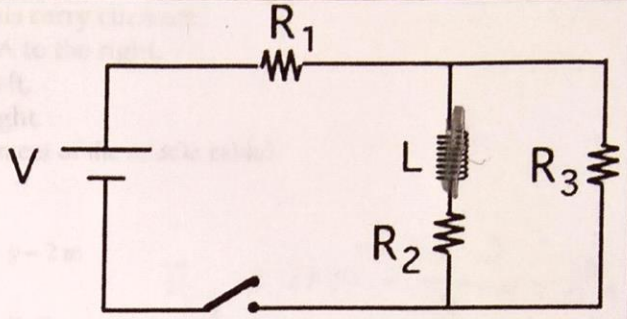
1. A	**This is to identify the exam version you have – IMPORTANT** **Mark the A**
2. B	**This is to identify the exam version you have – IMPORTANT** **Mark the B**
3. C 48	A cable with current flowing up, An electron, right of the cable, flies away from the cable. The electron will feel a force in which direction? a) Zero force b) ↑ c) ↓ d) ⊗ e) ⊙ $e^- \rightarrow$ ⊗ B
4. A 58	A long, straight wire carries a current flowing right. A rectangular conducting loop lies in the same plane as the wire. In order to induce a current flowing clockwise in the loop, you have to a. Move the loop towards the wire. b. Move the loop away from the wire. c. Move the loop parallel to the wire to the right d. Move the loop parallel to the wire to the left e. impossible to get that done.  i) ⊙ f) ⊙ Result ⊗
5. A 81	$R_1 = 1\ \Omega$; $R_2 = 3\ \Omega$; $R_3 = 6\ \Omega$; $L = 5$ H; $\Delta V_{Battery} = 21$ V The very first moment after the switch was closed, the voltage across R_2 is a) Zero V b) 7 V c) 14 V d) 18 V e) 21 V  $I_2 = I_{R2} = 0 \Rightarrow \Delta V_{R2} = 0$

6. C 71

$R_1 = 1\ \Omega$; $R_2 = 3\ \Omega$; $R_3 = 6\ \Omega$;
$L = 5$ H; $\Delta V_{Battery} = 21$ V

After the switch was closed and we waited a long time, the voltage across R_2 is

a) Zero V
b) 7 V
c) 14 V
d) 18 V
e) 21 V



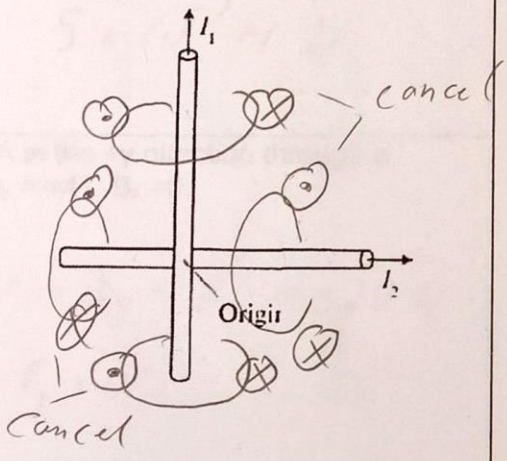
$\Delta V_{R_2} = \Delta V_{R_3}$ $R_2 \| R_3 = 2\ \Omega$ $\Delta V_{R_{2,3}} = 14$V

7. E 90

Two long straight wires cross at the origin, each carrying a current of 1 A in the direction shown.

At which of the following points must the magnetic field due to the 2 wires be **NOT zero**?
[A=(1,1); B=(-1,1); C=(-1,-1); D=(1,-1)

A. A, B, C, and D
B. A and C
C. A and D
D. B and C
E. B and D



8. C 38

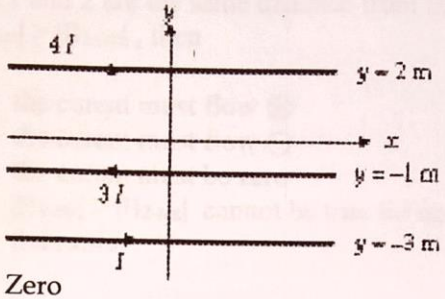
A square loop of wire has sides of length 5 cm, and is completely placed in a magnetic field with magnitude given by $B = 10t^2$, where B is in Tesla, t is in seconds. The normal of the loop area and B are parallel and pointing out of the page. At t= 4 s the magnitude of induced voltage is:

1) 100 mV
2) 400 mV
3) 200 mV
4) Zero
5) Something else

$\Delta V = -\frac{d\Phi_B}{dt}$ $\Phi_B = B \cdot A$
$= A \cdot 10t^2$
$= -A\,10 \cdot 2 \cdot t$ /@4s
$= 2.5 \cdot 10^{-1}\,m \cdot 10 \cdot 2 \cdot 4$ V
$= 200$ mV

9. F

Three long wires parallel to the x axis carry currents.
If the upper wire (at y = 2 m) has 4 A to the right,
the middle (at y = -1 m) 3 A to the left,
the lowest (at y = -3 m) 1 A to the right.
What is the net force on a 1 m long segment of the middle cable?



a) Zero
b) 11×10^{-7} N; ↑
c) 5×10^{-7} N; ↑
d) 11×10^{-7} N; ↓
e) 5×10^{-7} N; ↓

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$F_{1,2} = 2\times10^{-7} \cdot \frac{4\cdot3}{3} N = 8\times10^{-7} N \downarrow$

$F_{2,3} = 2\times10^{-7} \cdot \frac{3\cdot1}{2} N = 3\times10^{-7} N \uparrow$

$5\times10^{-7} N \downarrow$

10. B

A wire of length 1 m carries a current of 10 A in the +y direction through a magnetic field with components B_x = +2T; B_y = +4T; B_z = 0.
The magnetic force on the wire is

a) F_x = 20 N; F_y = 40 N; F_z = 0 N
b) F_x = 0 N; F_y = 0 N; F_z = -20 N
c) F_x = 0 N; F_y = 0 N; F_z = 0 N
d) F_x = 0 N; F_y = 20 N; F_z = -20 N
e) None of these

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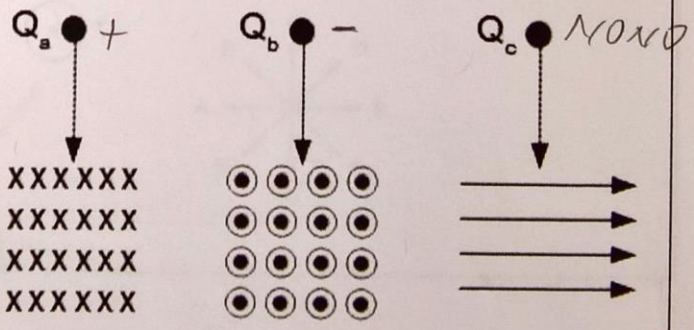
$F_z = -I_y \cdot B_x = -20$ N

$F_x = F_y = 0$

11. E

A charged particle flies ↓and enters the regions with magnetic field as indicated below.
In each case the particle is supposed to feel a force pointing to the right (→).
The charges must be positive (+) or negative (-) ?

a) Q_a +, Q_b +, Q_c +
b) Q_a -, Q_b +, Q_c +
c) Q_a +, Q_b -, Q_c +
d) Q_a -, Q_b +, Q_c impossible
e) Q_a +, Q_b -, Q_c impossible



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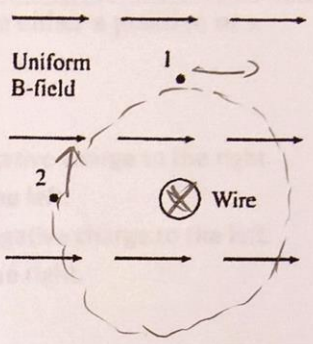
12. A

A long straight wire, perpendicular to the page passes through a uniform magnetic field [with 3 T strength] which points to the right.
The net magnetic field values at points 1 and 2 are $B_{1\text{-net}}$ and $B_{2\text{-net}}$.
Points 1 and 2 are the same distance from the wire.
If $|B_{1\text{-net}}| > |B_{2\text{-net}}|$, then



1) the curent must flow ⊗
2) the curent must flow ⊙
3) the curent must be zero
4) $|B_{1\text{-net}}| > |B_{2\text{-net}}|$ cannot be true for any current in the cable.

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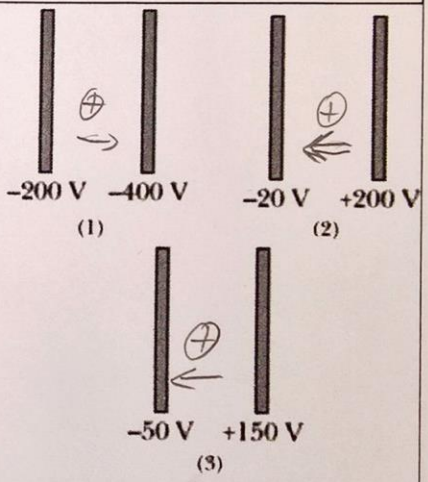
13. D

The figure shows three pairs of parallel plates with the same separation of 1 m, and the electric potential of each plate.
Placing a positive +1 C charge in the center of the electric field for each of the 3 cases would result in forces on the charges like:
[comparing magnitude and showing direction]



a) $|F_1| > |F_2| > |F_3|$; $F_1 \rightarrow$; $F_2 \rightarrow$; $F_3 \rightarrow$
b) $|F_1| > |F_2| > |F_3|$; $F_1 \rightarrow$; $F_2 \leftarrow$; $F_3 \leftarrow$
c) $|F_2| > |F_1| = |F_3|$; $F_1 \rightarrow$; $F_2 \rightarrow$; $F_3 \rightarrow$
d) $|F_2| > |F_1| = |F_3|$; $F_1 \rightarrow$; $F_2 \leftarrow$; $F_3 \leftarrow$
e) Something else

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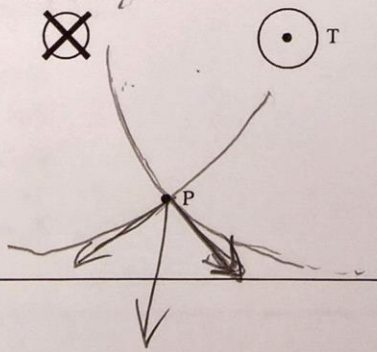
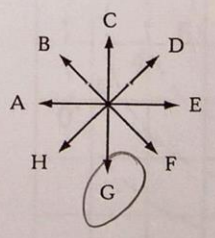
14. C

The point P lies along the perpendicular bisector of the line connecting two long straight wires S and T perpendicular to the page. A set of directions A through H is shown next to the diagram. When the two equal currents in the wires are directed one up out of the page the other down into the page, the direction of the magnetic field at P is closest to the direction of

1) E
2) F
3) G
4) H
5) A





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15. B

In a uniform magnetic field which point to the right you place either a positive or a negative charge at rest.
Which statement is correct?

1. The positive charge will experience a force to the left, the negative charge to the right.
2. Both positive and negative charge will experience a force to the left.
3. The positive charge will experience a force to the right, the negative charge to the left.
4. Both positive and negative charge will experience a force to the right.
5. Both positive and negative charge will experience no force.

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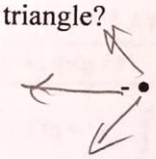
16. D

Three charges are placed at the corners of an equilateral triangle as shown. The charges are equal in magnitude, but differ in sign as shown. What direction is the force on the charge at the top of the triangle?



(a) ↑
(b) →
(c) ↓
(d) ←
(e) F = 0.

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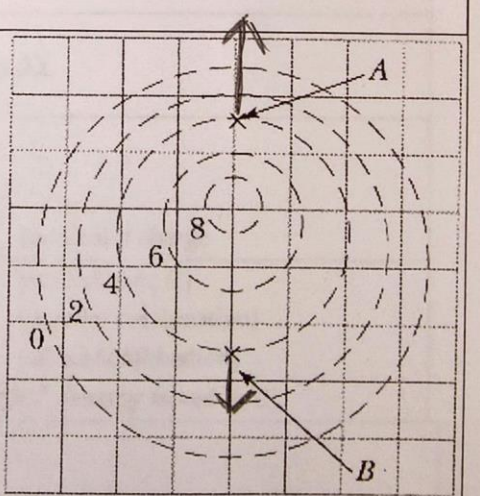
17. A

The figure shows the equipotential lines of an electric "landscape". The numbers show the level of the electric potential in Volt.
A positive +1 C charge placed either at point A or point B would feel a force [direction and relative magnitude] like:

1) $F_A\uparrow > F_B\downarrow$
2) $F_A\downarrow > F_B\uparrow$
3) $F_A\uparrow < F_B\downarrow$
4) $F_A\downarrow < F_B\uparrow$
5) $F_A\uparrow > F_B\uparrow$



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Kinematics	$\mathbf{v} = \mathbf{v}_0 + \mathbf{a}\cdot t$ $\mathbf{x} = \mathbf{x}_0 + \mathbf{v}_0\cdot t + \frac{1}{2}\cdot\mathbf{a}\cdot t^2$ $\mathbf{v}^2 = \mathbf{v}_0^2 + 2\mathbf{a}\cdot(\mathbf{x} - \mathbf{x}_0)$ $\bar{v} = (\mathbf{v} + \mathbf{v}_0) / 2$
Newton's Law	$\mathbf{F} = m\cdot\mathbf{a}$ $\mathbf{F}_{gravity} = m\cdot\mathbf{g}$ $\quad \mathbf{g} = 9.80\ m/s^2$
Conservation of Energy	$KE_1 + U_1 + W_{in/out} = KE_2 + U_2$
Energy	Kinetik (linear): $KE_{lin} = \frac{1}{2}\, m\mathbf{v}^2$ Potential (gravity): $U_g = m\,\mathbf{g}\,\mathbf{y}$
Work	$W = \mathbf{F}\cdot\mathbf{d} = F\,d\cos\theta$
Power (electrical)	$P = W/t = E/t$ $P = I\,\Delta V = I^2 R = (\Delta V)^2 / R$
Coulomb force	$\mathbf{F} = k_e\, q_1 q_2 / r^2$ along the connecting line
Electric field	$\mathbf{E} = \mathbf{F}/q = k_e \int_{volume} \frac{dq}{r^2}$ $\mathbf{E} = k_e\, q / r^2$ for a point charge / pointing radially $E = -gradient(V) = -\frac{dV}{dx}$
Electric flux	$\Phi_E = \int_{surface} \vec{E}\, d\vec{A}$
Gauss Law	$\Phi_E = \int_{closedsurface} \vec{E}\, d\vec{A} = q_{inside}/\varepsilon_o = 4\pi k_e \cdot q_{inside}$
Potential energy	$\underline{\Delta U} = U_B - U_A = -q\int_A^B \vec{E}\, d\vec{s} = \underline{q\,\Delta V}$
Potential	$\Delta V = \Delta U / q = -\int_A^B \vec{E}\, d\vec{s}$ $V = k_e q / r$ for a point charge
Capacitance	$C = Q/\Delta V$ $\quad [= \varepsilon_o A/d$ parallel plate C] $C_{eq} = C_1 + C_2 + C_3 + \ldots$ [parallel combination] $1/C_{eq} = 1/C_1 + 1/C_2 + 1/C_3 + \ldots$ [series combination] $U = Q^2/2C = \frac{1}{2}\, Q\,\Delta V = \frac{1}{2}\, C\,(\Delta V)^2$ [energy stored in C]
Charging/discharging of Capacitor	$q(t) = Q\cdot(1 - e^{-t/RC})$ $I(t) = (\Delta V/R)\cdot e^{-t/RC}$ $q(t) = Q\cdot e^{-t/RC}$ $I(t) = -(\Delta V/R)\cdot e^{-t/RC}$

Ohm's Law	$R = \Delta V/I = \rho \cdot l/A$ [ρ = resistivity = $1/\sigma$]
Resistivity / Resistance	$\rho = m_e / (n q^2 \tau)$ [τ = scattering time] $\rho = \rho_o [1 + \alpha(T - T_o)]$ [temperature dependence] $1/R_{eq} = 1/R_1 + 1/R_2 + 1/R_3 + \ldots$ [parallel] $R_{eq} = R_1 + R_2 + R_3 + \ldots$ [series]
Magnetic force	$\mathbf{F_B} = q \cdot \mathbf{v} \times \mathbf{B}$ $\mathbf{F_B} = I \cdot \mathbf{L} \times \mathbf{B}$ [force on straight conductor] $d\mathbf{F_B} = I \cdot d\mathbf{s} \times \mathbf{B}$ [force on conductor segment]
Force between parallel current carrying cables	attractive force for same current directions. repulsive force for opposite current directions. $F_B = \frac{\mu_o I_1 I_2}{2\pi a} * length$
Cyclotron motion [circular motion of a charge in a magnetic field]	$r = (mv) / (qB)$ [radius] $\omega = (qB) / m$ [frequency]
Magnetic Field by a current Ampere's Law	$d\mathbf{B} = \mu_o/4\pi \cdot (I\, ds \times \hat{r}) / r^2$ [Biot-Savart Law] $B = (\mu_o I) / 2\pi a$ [long straight wire] $\oint_{closedloop} \vec{B} d\vec{s} = \mu_0 I$
Magnetic Flux	$\Phi_B = \int_{surface} \vec{B} d\vec{A}$
Faraday's Law of Induction	$emf = (\Delta V =) - N \cdot (d\Phi_B / dt)$
Lenz' Law	the polarity of the induced emf is such that it wants to act 'against' the cause.
Inductor	$emf = (\Delta V =) - L \cdot dI/dt$
LR circuit	$I = \Delta V/R \cdot (1 - e^{-t/\tau})$ 'switch on' $I = \Delta V/R \cdot e^{-t/\tau}$ 'switch off' $\tau = L/R$
electron mass proton mass elementary charge Coulomb constant Permittivity of free space Permeability of free space	$m_e = 9 \times 10^{-31}$ kg $m_p = 2 \times 10^{-27}$ kg $e = 1.6 \times 10^{-19}$ C [electron: -e ; proton: +e] $k_e = 9 \times 10^9$ Nm^2/C^2 $\varepsilon_o = 9 \times 10^{-12}$ C^2/Nm^2 [$k_e = 1/4\pi\varepsilon_o$] $\mu_o = 4\pi \times 10^{-7}$ H/m ⊗⊙↖↗↙↘←→↑↓