CONSTANTS

Description	Value
Acceleration of gravity on Earth (g)	9.80 m/s ²
Speed of light in a vacuum (c)	$3.00 \times 10^8 \text{ m/s}$
Planck's constant (h)	$6.63 \times 10^{-34} \text{ J} \cdot \text{s} = 4.14 \times 10^{-15} \text{ eV} \cdot \text{s}$
Electron rest mass (m_e)	$9.11 \times 10^{-31} \text{ kg}$
Proton rest mass (m_p)	$1.67 \times 10^{-27} \text{ kg}$
Elementary charge (e)	$1.60 \times 10^{-19} \mathrm{C}$
Coulomb's constant (k_e)	$8.99 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2$
Boltzmann constant (k_b)	$1.38 \times 10^{-23} \text{ J/K}$
Gas constant (R)	8.31 J/(mol•K)
Gravitational constant (G)	$6.67 \times 10^{-11} \text{ N} \cdot \text{m}^2/\text{kg}^2$
Permeability of free space (μ_0)	$4\pi \times 10^{-7} \text{ T} \cdot \text{m/A}$
Avogadro's number (N_A)	6.02×10^{23} particles/mole
Heat of fusion of water (L_f)	$3.33 \times 10^5 \mathrm{J/kg}$
Heat of vaporization of water (L_v)	$2.26 imes 10^6 ext{ J/kg}$
Specific heat of water (c_w)	$4.19 \times 10^3 \text{ J/(kg} \bullet^{\circ}\text{C)}$
Density of water (ρ_w)	$1.00\times10^3~kg/m^3$

FORMULAS

Mathematics	Force and Motion
$C = 2\pi r$	$v_f = v_i + at$
$A=\pi r^2$	$x_{f} = x_{i} + v_{i}t + \frac{1}{2}at^{2}$ $v_{f}^{2} - v_{i}^{2} = 2a(x_{f} - x_{i})$
$SA = 4\pi r^2$	
$V = \frac{4}{3}\pi r^3$	$a_{\rm c} = \frac{v^2}{r}$
	$\Sigma \mathbf{F} = m\mathbf{a}$
(a, b) denotes a vector with an x-component of a	F = -kx
and a y -component of b .	$F \leq \mu N$
	$F = \frac{Gm_1m_2}{r^2}$
	$\theta_f = \theta_i + \omega_i t + \frac{1}{2} \alpha t^2$
	$\omega_f = \omega_i + \alpha t$
	$v = r\omega$
	$a = r\alpha$
	$\mathbf{r}_{cm} = \frac{\sum m\mathbf{r}}{\sum m}$
	$I = \sum mr^2$
	$\tau = \mathbf{r} \times \mathbf{F}$
	$\sum \tau = I \alpha$
	$P = \rho g h$
	$F = \rho V g$
	$A_1 v_1 = A_2 v_2$
	$P + \frac{1}{2}\rho v^2 + \rho gy = \text{constant}$

FORMULAS (continued)

$W = Fd \cos \theta$ $P = \frac{\Delta W}{\Delta t}$ $KE = \frac{1}{2}mv^{2}$ $E = \frac{F}{q_{0}}$ $PE = mgh$ $PE = qV$ $PE = \frac{1}{2}kx^{2}$ $V = -Ed$ $V = \frac{k_{c}q}{r}$ $\Delta p = F\Delta t$ $\Delta l = \alpha l_{0}\Delta T$ $Q = mc\Delta T$ $Q = mL$ $\frac{\Delta Q}{\Delta t} = \frac{k\Delta \Delta T}{d}$ $PV = nRT$ $\frac{1}{2}mv^{2} = \frac{3}{2}k_{0}T$ $\Delta E = Q - W$ $W = P\Delta V$ $e = \frac{T_{h} - T_{c}}{T_{h}}$ $KE = \frac{1}{2}I\omega^{2}$ $E = \frac{F}{q_{0}}$ $V = \frac{F}{q_{0}}$ $V = RT$ $R = \frac{\rho l}{A}$ $V = IR$ $R = \sum R_{l}$ $\frac{1}{R} = \sum \frac{1}{R_{l}}$ $P = IV$ $C = \frac{Q}{V}$ $F = qv \times B$ $F = Il \times B$ $E = \frac{\mu_{0}l}{l}$		· · ·
$P = \frac{\Delta W}{\Delta t}$ $KE = \frac{1}{2}mv^{2}$ $E = \frac{F}{q_{0}}$ $PE = mgh$ $PE = qV$ $V = -Ed$ $V = \frac{k_{e}q}{r}$ $\Delta \mathbf{p} = \mathbf{F}\Delta t$ $\Delta \mathbf{l} = \alpha l_{0}\Delta T$ $Q = mc\Delta T$ $Q = mL$ $\frac{\Delta Q}{\Delta t} = \frac{k\Delta \Delta T}{d}$ $PV = nRT$ $\frac{1}{2}m\overline{v^{2}} = \frac{3}{2}k_{b}T$ $\Delta E = Q - W$ $W = P\Delta V$ $e = \frac{T_{h} - T_{c}}{T_{h}}$ $KE = \frac{1}{2}I\omega^{2}$ $E = \frac{F}{q_{0}}$ $V = LR$ $R = \frac{F}{q_{0}}$ $V = RR$ $R = \frac{\rho l}{R}$ $R = \sum R_{i}$ $R = \sum \frac{1}{R_{i}}$ $R = \sum \frac{1}{R_{i}}$ $P = IV$ $C = \frac{Q}{V}$ $C = \sum C_{i}$ $F = q\mathbf{v} \times \mathbf{B}$ $F = Il \times \mathbf{B}$ $B = \frac{\mu_{0}l}{l}$	Energy, Momentum, and Heat Transfer	Electricity and Magnetism
$P = \frac{\Delta W}{\Delta L}$ $KE = \frac{1}{2}mv^{2}$ $PE = mgh$ $PE = qV$ $PE = \frac{1}{2}kx^{2}$ $V = -Ed$ $V = \frac{k_{s}q}{r}$ $\Delta p = F\Delta t$ $\Delta l = \alpha l_{0}\Delta T$ $Q = mc\Delta T$ $Q = mL$ $\frac{\Delta Q}{\Delta l} = \frac{k\Delta \Delta T}{d}$ $PV = nR$ $l = \sum \frac{1}{R_{i}}$ $PV = nR$ $l = \sum \frac{1}{R_{i}}$ $PV = nR$ $l = \sum \frac{1}{R_{i}}$ $P = IV$ $l = \frac{1}{2}mv^{2} = \frac{3}{2}k_{b}T$ $\Delta E = Q - W$ $l = \sum \frac{1}{C}$ $E = \frac{V}{q_{0}}$ $V = RR$ $V = RR$ $R = \sum R_{i}$ $R = R_{i}$ $R = \sum R_{i}$ $R = R_{i}$ $R = \sum R_{i}$ $R = R_{i}$	$W = Fd \cos \theta$	$k_e q_1 q_2$
$KE = \frac{1}{2}mv^{2}$ $PE = mgh$ $PE = qV$ $V = -Ed$ $V = \frac{k_{e}q}{r}$ $\Delta \mathbf{p} = \mathbf{F}\Delta t$ $\Delta \mathbf{l} = \alpha l_{0}\Delta T$ $Q = mc\Delta T$ $Q = mL$ $R = \sum_{i} \frac{1}{R_{i}}$ $PV = nRT$ $\frac{1}{2}m\overline{v^{2}} = \frac{3}{2}k_{b}T$ $\Delta E = Q - W$ $W = P\Delta V$ $e = \frac{T_{h} - T_{c}}{T_{h}}$ $KE = \frac{1}{2}I\omega^{2}$ $L = \mathbf{r} \times \mathbf{p}$ $E = \frac{\mathbf{F}}{q_{0}}$ $PE = qV$ $V = AV$ $V = RT$ $R = \sum_{i} \frac{1}{R_{i}}$ $P = IV$ $C = \frac{Q}{V}$ $C = \sum_{i} C_{i}$ $F = q\mathbf{v} \times \mathbf{B}$ $F = Il \times \mathbf{B}$ $B = \frac{\mu_{0}l}{2\pi r}$	$P = \frac{\Delta W}{\Delta t}$	$F = \frac{1}{r^2}$
$PE = mgh$ $PE = \frac{1}{2}kx^{2}$ $V = -Ed$ $V = \frac{k_{c}q}{r}$ $\Delta \mathbf{p} = \mathbf{F}\Delta t$ $\Delta \ell = \alpha \ell_{0}\Delta T$ $Q = mc\Delta T$ $Q = mL$ $\frac{\Delta Q}{\Delta t} = \frac{k\Delta\Delta T}{d}$ $PV = nRT$ $\frac{1}{2}m\overline{v^{2}} = \frac{3}{2}k_{b}T$ $\Delta E = Q - W$ $W = P\Delta V$ $e = \frac{T_{h} - T_{c}}{T_{h}}$ $KE = \frac{1}{2}I\omega^{2}$ $L = \mathbf{r} \times \mathbf{p}$ $V = \frac{L}{V}$ $V = RR$ $R = \sum_{k} R_{i}$ $R = \sum$	$KE = \frac{1}{2}mv^2$	$\mathbf{E} = \frac{\mathbf{F}}{q_0}$
$PE = \frac{1}{2}kx^{2}$ $\mathbf{p} = m\mathbf{v}$ $\Delta \mathbf{p} = \mathbf{F}\Delta t$ $\Delta \ell = \alpha \ell_{0}\Delta T$ $Q = mc\Delta T$ $Q = mL$ $\frac{\Delta Q}{\Delta t} = \frac{k\Delta \Delta T}{d}$ $PV = nRT$ $\frac{1}{2}m\overline{v^{2}} = \frac{3}{2}k_{b}T$ $\Delta E = Q - W$ $W = P\Delta V$ $\ell = \frac{T_{h} - T_{c}}{T_{h}}$ $KE = \frac{1}{2}I\omega^{2}$ $L = \mathbf{r} \times \mathbf{p}$ $V = \frac{k_{e}q}{r}$ $R = \frac{k_{e}q}{r}$ $R = \frac{\rho\ell}{A}$ $R = \frac{\rho\ell}{A}$ $V = IR$ $R = \sum R_{i}$ $R = \sum \frac{1}{R_{i}}$ $P = IV$ $C = \frac{Q}{V}$ $C = \sum C_{i}$ $F = q\mathbf{v} \times \mathbf{B}$ $F = I\ell \times \mathbf{B}$	PE = mgh	PE = qV
$\begin{aligned} \mathbf{p} &= m\mathbf{v} \\ \Delta \mathbf{p} &= \mathbf{F} \Delta t \end{aligned} \qquad \qquad V &= \frac{k_e q}{r} \\ \Delta \ell &= \alpha \ell_0 \Delta T \qquad \qquad R = \frac{\rho \ell}{A} \end{aligned} \qquad \qquad V &= IR \end{aligned} \qquad \qquad V &= IV \end{aligned} \qquad \qquad V &= I \Rightarrow IV \end{aligned} \qquad \qquad V &= I \Rightarrow IV \Rightarrow IF \Rightarrow II \Rightarrow IF \Rightarrow IF \Rightarrow II \Rightarrow IF \Rightarrow IF$	$PE = \frac{1}{2}kx^2$	V = -Ed
$\Delta \mathbf{p} = \mathbf{F} \Delta t$ $\Delta \ell = \alpha \ell_0 \Delta T$ $Q = mc \Delta T$ $V = IR$ $R = \sum R_i$ $\frac{\Delta Q}{\Delta t} = \frac{kA\Delta T}{d}$ $PV = nRT$ $\frac{1}{2}m\overline{v^2} = \frac{3}{2}k_bT$ $\Delta E = Q - W$ $W = P\Delta V$ $e = \frac{T_h - T_c}{T_h}$ $KE = \frac{1}{2}I\omega^2$ $\mathbf{L} = \mathbf{r} \times \mathbf{p}$ $R = \frac{\rho \ell}{A}$ $V = IR$ $R = \sum R_i$ $\ell = R + \sum R_i$	$\mathbf{p} = m\mathbf{v}$	$V = \frac{k_e q}{r}$
$\Delta \ell = \alpha \ell_0 \Delta T$ $Q = mc\Delta T$ $Q = mL$ $\frac{\Delta Q}{\Delta l} = \frac{k\Delta \Delta T}{d}$ $PV = nRT$ $\frac{1}{2}m\overline{v^2} = \frac{3}{2}k_bT$ $\Delta E = Q - W$ $W = P\Delta V$ $e = \frac{T_h - T_c}{T_h}$ $KE = \frac{1}{2}I\omega^2$ $L = \mathbf{r} \times \mathbf{p}$ $R = \frac{\rho\ell}{A}$ $V = IR$ $R = \sum R_i$ $\frac{1}{R} = \sum \frac{1}{R_i}$ $P = IV$ $C = \frac{Q}{V}$ $C = \sum C_i$ $F = q\mathbf{v} \times \mathbf{B}$ $F = I\ell \times \mathbf{B}$	$\Delta \mathbf{p} = \mathbf{F} \Delta t$	
$Q = mL$ $Q = mL$ $R = \sum R_i$ $\frac{\Delta Q}{\Delta t} = \frac{kA\Delta T}{d}$ $PV = nRT$ $\frac{1}{2}m\overline{v^2} = \frac{3}{2}k_bT$ $\Delta E = Q - W$ $W = P\Delta V$ $e = \frac{T_h - T_c}{T_h}$ $KE = \frac{1}{2}I\omega^2$ $L = \mathbf{r} \times \mathbf{p}$ $V = IR$ $R = \sum R_i$ $P = IV$ $C = \frac{Q}{V}$ $C = \frac{Q}{V}$ $C = \sum C_i$ $F = q\mathbf{v} \times \mathbf{B}$ $F = I\ell \times \mathbf{B}$ $B = \frac{\mu_0 I}{2\pi r}$	$\Delta \ell = \alpha \ell_0 \Delta T$	$R = \frac{\rho \ell}{A}$
$Q = mL$ $R = \sum R_i$ $\frac{\Delta Q}{\Delta I} = \frac{kA\Delta T}{d}$ $PV = nRT$ $\frac{1}{2}m\overline{V^2} = \frac{3}{2}k_bT$ $C = \frac{Q}{V}$ $\Delta E = Q - W$ $C = \sum C_i$ $W = P\Delta V$ $e = \frac{T_h - T_c}{T_h}$ $KE = \frac{1}{2}I\omega^2$ $L = \mathbf{r} \times \mathbf{p}$ $R = \sum R_i$ $P = IV$ $C = \frac{Q}{V}$ $C = \frac{Q}{V}$ $F = IV$ $F = q\mathbf{v} \times \mathbf{B}$ $F = Il \times \mathbf{B}$ $B = \frac{\mu_0 I}{2\pi r}$	$Q = mc\Delta T$	V = IR
$ \frac{\Delta Q}{\Delta t} = \frac{kA\Delta T}{d} $ $ PV = nRT $ $ \frac{1}{2}mv^{2} = \frac{3}{2}k_{b}T $ $ \Delta E = Q - W $ $ W = P\Delta V $ $ e = \frac{T_{h} - T_{c}}{T_{h}} $ $ KE = \frac{1}{2}I\omega^{2} $ $ L = \mathbf{r} \times \mathbf{p} $ $ \frac{1}{R} = \sum \frac{1}{R_{i}} $ $ P = IV $ $ C = \frac{Q}{V} $ $ C = \sum C_{i} $ $ \mathbf{F} = q\mathbf{v} \times \mathbf{B} $ $ \mathbf{F} = I\ell \times \mathbf{B} $ $ B = \frac{\mu_{0}I}{2\pi r} $	Q = mL	$R = \sum R_i$
$PV = nRT$ $\frac{1}{2} m \overline{v^2} = \frac{3}{2} k_b T$ $\Delta E = Q - W$ $W = P \Delta V$ $C = \frac{\Sigma}{C_i}$ $W = \frac{T_h - T_c}{T_h}$ $KE = \frac{1}{2} I \omega^2$ $L = \mathbf{r} \times \mathbf{p}$ $P = IV$ $C = \frac{Q}{V}$ $C = \Sigma C_i$ $F = q \mathbf{v} \times \mathbf{B}$ $F = I \ell \times \mathbf{B}$ $B = \frac{\mu_0 \ell}{2\pi r}$	$\frac{\Delta Q}{\Delta t} = \frac{kA\Delta T}{d}$	$\frac{1}{R} = \sum \frac{1}{R_i}$
$\frac{1}{2}m\overline{v^{2}} = \frac{3}{2}k_{b}T$ $C = \frac{Q}{V}$ $C = \Sigma C_{i}$ $W = P\Delta V$ $\frac{1}{C} = \sum \frac{1}{C_{i}}$ $F = q\mathbf{v} \times \mathbf{B}$ $KE = \frac{1}{2}I\omega^{2}$ $\mathbf{L} = \mathbf{r} \times \mathbf{p}$ $F = \frac{\mu_{0}I}{2\pi r}$	PV = nRT	P = IV
$\Delta E = Q - W$ $C = \sum C_i$ $W = P\Delta V$ $\frac{1}{C} = \sum \frac{1}{C_i}$ $\mathbf{F} = q\mathbf{v} \times \mathbf{B}$ $\mathbf{F} = I\mathbf{\ell} \times \mathbf{B}$ $\mathbf{E} = \frac{1}{2}I\omega^2$ $\mathbf{L} = \mathbf{r} \times \mathbf{p}$ $E = \frac{\mu_0 I}{2\pi r}$	$\frac{1}{2}m\overline{v^2} = \frac{3}{2}k_bT$	$C = \frac{Q}{V}$
$W = P\Delta V$ $\frac{1}{C} = \sum \frac{1}{C_i}$ $e = \frac{T_h - T_c}{T_h}$ $KE = \frac{1}{2}I\omega^2$ $L = \mathbf{r} \times \mathbf{p}$ $F = \mathbf{I}\ell \times \mathbf{B}$ $B = \frac{\mu_0 I}{2\pi r}$	$\Delta E = Q - W$	$C = \sum C_i$
$e = \frac{T_h - T_c}{T_h}$ $KE = \frac{1}{2}I\omega^2$ $\mathbf{L} = \mathbf{r} \times \mathbf{p}$ $\mathbf{F} = q\mathbf{v} \times \mathbf{B}$ $\mathbf{F} = I\boldsymbol{\ell} \times \mathbf{B}$ $B = \frac{\mu_0 I}{2\pi r}$	$W = P\Delta V$	$\frac{1}{C} = \sum \frac{1}{C_i}$
$KE = \frac{1}{2}I\omega^2$ $\mathbf{L} = \mathbf{r} \times \mathbf{p}$ $B = \frac{\mu_0 I}{2\pi r}$	$e=rac{T_h-T_c}{T_h}$	$\mathbf{F} = q\mathbf{v} \times \mathbf{B}$
$\mathbf{L} = \mathbf{r} \times \mathbf{p}$ $B = \frac{\mu_0 I}{2\pi r}$	$KF - \frac{1}{2}I\omega^2$	$\mathbf{F} = I\boldsymbol{\ell} \times \mathbf{B}$
	$\mathbf{L} = \mathbf{r} \times \mathbf{p}$	$B = \frac{\mu_0 I}{2\pi r}$

 $\phi = B_{\perp}A$

In questions on electricity and magnetism, the term *current* refers to "conventional current" and the use of

the right-hand rule is assumed.

 $L = I\omega$

 $T_k = 273 + T_c$

FORMULAS (continued)

Waves, Sound, and Light	Modern Physics
$T = \frac{2\pi}{\omega}$	E = hf
$a = -\omega^2 x$	$E = \gamma mc^2$
$x = A \sin \omega t$	y - <u>1</u>
$T=2\pi\sqrt{rac{m}{k}}$	$E = \gamma mc^2$ $\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$
$T = 2\pi \sqrt{\frac{L}{g}}$	$hf = \phi + eV$ $\Delta x \Delta p \ge h$
$v = f\lambda$	$\Delta x \Delta p \ge h$
$v = \sqrt{\frac{T}{\mu}}$	$\Delta E \Delta t \geq h$
$v = \sqrt{\frac{\gamma RT}{M}}$	
$2L = n\lambda$, <i>n</i> is an integer	$p = \frac{h}{\lambda}$
$4L = n\lambda$, <i>n</i> is odd	
$n_1 \sin \theta_1 = n_2 \sin \theta_2$	
$n=\frac{c}{v}$	
$\frac{1}{f} = \frac{1}{s_i} + \frac{1}{s_0}$	
$M = \frac{h_i}{h_0} = -\frac{s_i}{s_0}$	
$d\sin\theta=m\lambda$	
$I = I_0 \cos^2 \theta$	

NOTES FOR PHYSICS TEST

Not all formulas necessary are listed, nor are all formulas listed used on this test.

In questions on electricity and magnetism, the term *current* refers to "conventional current" and the use of the right-hand rule is assumed.