



National
Qualifications
2024

X857/77/11

**Physics
Relationships sheet**

THURSDAY, 25 APRIL
9:00 AM – 12:00 NOON



Relationships required for Physics Advanced Higher

$$v = \frac{ds}{dt}$$

$$a = \frac{dv}{dt} = \frac{d^2s}{dt^2}$$

$$v = u + at$$

$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

$$\omega = \frac{d\theta}{dt}$$

$$\alpha = \frac{d\omega}{dt} = \frac{d^2\theta}{dt^2}$$

$$\omega = \omega_o + \alpha t$$

$$\omega^2 = \omega_o^2 + 2\alpha\theta$$

$$\theta = \omega_o t + \frac{1}{2}\alpha t^2$$

$$s = r\theta$$

$$v = r\omega$$

$$a_t = r\alpha$$

$$\omega = \frac{2\pi}{T}$$

$$\omega = 2\pi f$$

$$a_r = \frac{v^2}{r} = r\omega^2$$

$$F = \frac{mv^2}{r} = mr\omega^2$$

$$I = \sum mr^2$$

$$\tau = Fr$$

$$\tau = I\alpha$$

$$L = mvr = mr^2\omega$$

$$L = I\omega$$

$$E_{k(\text{rotational})} = \frac{1}{2}I\omega^2$$

$$E_P = E_{k(\text{translational})} + E_{k(\text{rotational})}$$

$$F = \frac{GMm}{r^2}$$

$$F = \frac{GMm}{r^2} = \frac{mv^2}{r} = mr\omega^2 = mr\left(\frac{2\pi}{T}\right)^2$$

$$V = -\frac{GM}{r}$$

$$E_P = Vm = -\frac{GMm}{r}$$

$$v_{\text{esc}} = \sqrt{\frac{2GM}{r}}$$

$$r_{\text{Schwarzschild}} = \frac{2GM}{c^2}$$

$$b = \frac{L}{4\pi d^2}$$

$$\frac{P}{A} = \sigma T^4$$

$$L = 4\pi r^2 \sigma T^4$$

$$E = hf$$

$$mvr = \frac{nh}{2\pi}$$

$$\lambda = \frac{h}{p}$$

$$\Delta x \Delta p_x \geq \frac{h}{4\pi}$$

$$\Delta E \Delta t \geq \frac{h}{4\pi}$$

$$F = qvB$$

$$F = \frac{mv^2}{r}$$

$$F = -ky$$

$$\omega = 2\pi f = \frac{2\pi}{T}$$

$$a = \frac{d^2 y}{dt^2} = -\omega^2 y$$

$$y = A \cos \omega t \quad \text{or} \quad y = A \sin \omega t$$

$$v = \pm \omega \sqrt{(A^2 - y^2)}$$

$$E_k = \frac{1}{2} m \omega^2 (A^2 - y^2)$$

$$E_p = \frac{1}{2} m \omega^2 y^2$$

$$E = kA^2$$

$$y = A \sin 2\pi \left(ft - \frac{x}{\lambda} \right)$$

$$\phi = \frac{2\pi x}{\lambda}$$

$$opd = n \times gpd$$

$$opd = m\lambda \quad \text{or} \quad \left(m + \frac{1}{2} \right) \lambda \quad \text{where } m = 0, 1, 2, \dots$$

$$\Delta x = \frac{\lambda l}{2d}$$

$$d = \frac{\lambda}{4n}$$

$$\Delta x = \frac{\lambda D}{d}$$

$$n = \tan i_p$$

$$F = \frac{Q_1 Q_2}{4\pi \epsilon_0 r^2}$$

$$V = \frac{Q}{4\pi \epsilon_0 r}$$

$$E = \frac{Q}{4\pi \epsilon_0 r^2}$$

$$F = QE$$

$$V = Ed$$

$$W = QV$$

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

$$B = \frac{\mu_0 I}{2\pi r}$$

$$F = IlB \sin \theta$$

$$F = qvB$$

$$\tau = RC$$

$$X_C = \frac{V}{I}$$

$$X_C = \frac{1}{2\pi fC}$$

$$\varepsilon = -L \frac{dI}{dt}$$

$$E = \frac{1}{2} LI^2$$

$$X_L = \frac{V}{I}$$

$$X_L = 2\pi fL$$

$$c = \frac{1}{\sqrt{\epsilon_0 \mu_0}}$$

$$\Delta W = \sqrt{\Delta X^2 + \Delta Y^2 + \Delta Z^2}$$

$$\frac{\Delta W}{W} = \sqrt{\left(\frac{\Delta X}{X} \right)^2 + \left(\frac{\Delta Y}{Y} \right)^2 + \left(\frac{\Delta Z}{Z} \right)^2}$$

$$\left(\frac{\Delta W^n}{W^n} \right) = n \left(\frac{\Delta W}{W} \right)$$

$$d = \bar{v}t$$

$$s = \bar{v}t$$

$$v = u + at$$

$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

$$s = \frac{1}{2}(u + v)t$$

$$W = mg$$

$$F = ma$$

$$E_W = Fd$$

$$E_P = mgh$$

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

$$P = \frac{E}{t}$$

$$p = mv$$

$$Ft = mv - mu$$

$$F = G \frac{Mm}{r^2}$$

$$t' = \frac{t}{\sqrt{1 - \left(\frac{v}{c}\right)^2}}$$

$$l' = l\sqrt{1 - \left(\frac{v}{c}\right)^2}$$

$$f_o = f_s \left(\frac{v}{v \pm v_s} \right)$$

$$z = \frac{\lambda_{\text{observed}} - \lambda_{\text{rest}}}{\lambda_{\text{rest}}}$$

$$z = \frac{v}{c}$$

$$v = H_0 d$$

$$W = QV$$

$$E = mc^2$$

$$E = hf$$

$$E_K = hf - hf_0$$

$$E_2 - E_1 = hf$$

$$T = \frac{1}{f}$$

$$v = f\lambda$$

$$d \sin \theta = m\lambda$$

$$n = \frac{\sin \theta_1}{\sin \theta_2}$$

$$\frac{\sin \theta_1}{\sin \theta_2} = \frac{\lambda_1}{\lambda_2} = \frac{v_1}{v_2}$$

$$\sin \theta_c = \frac{1}{n}$$

$$I = \frac{k}{d^2}$$

$$I = \frac{P}{A}$$

$$\text{path difference} = m\lambda \quad \text{or} \quad \left(m + \frac{1}{2}\right)\lambda \quad \text{where } m = 0, 1, 2, \dots$$

$$\text{random uncertainty} = \frac{\text{max. value} - \text{min. value}}{\text{number of values}}$$

$$V_{\text{peak}} = \sqrt{2}V_{\text{rms}}$$

$$I_{\text{peak}} = \sqrt{2}I_{\text{rms}}$$

$$Q = It$$

$$V = IR$$

$$P = IV = I^2 R = \frac{V^2}{R}$$

$$R_T = R_1 + R_2 + \dots$$

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$$

$$E = V + Ir$$

$$V_1 = \left(\frac{R_1}{R_1 + R_2} \right) V_S$$

$$\frac{V_1}{V_2} = \frac{R_1}{R_2}$$

$$C = \frac{Q}{V}$$

$$E = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2} \frac{Q^2}{C}$$

Additional relationships

Circle

$$\text{circumference} = 2\pi r$$

$$\text{area} = \pi r^2$$

Sphere

$$\text{area} = 4\pi r^2$$

$$\text{volume} = \frac{4}{3}\pi r^3$$

Trigonometry

$$\sin \theta = \frac{\text{opposite}}{\text{hypotenuse}}$$

$$\cos \theta = \frac{\text{adjacent}}{\text{hypotenuse}}$$

$$\tan \theta = \frac{\text{opposite}}{\text{adjacent}}$$

$$\sin^2 \theta + \cos^2 \theta = 1$$

Moment of inertia

point mass

$$I = mr^2$$

rod about centre

$$I = \frac{1}{12}ml^2$$

rod about end

$$I = \frac{1}{3}ml^2$$

disc about centre

$$I = \frac{1}{2}mr^2$$

sphere about centre

$$I = \frac{2}{5}mr^2$$

Table of standard derivatives

| $f(x)$ | $f'(x)$ |
|-----------|--------------|
| $\sin ax$ | $a \cos ax$ |
| $\cos ax$ | $-a \sin ax$ |

Table of standard integrals

| $f(x)$ | $\int f(x)dx$ |
|-----------|---------------------------|
| $\sin ax$ | $-\frac{1}{a}\cos ax + C$ |
| $\cos ax$ | $\frac{1}{a}\sin ax + C$ |

Electron arrangements of elements

Group 1 Group 2
(1)

| | |
|---|---|
| 1 H 1 Hydrogen | 4 Be 2,2 Beryllium |
| 3 Li 2,1 Lithium | |
| 11 Na 2,8,1 Sodium | 12 Mg 2,8,2 Magnesium |
| 19 K 2,8,8,1 Potassium | 20 Ca 2,8,8,2 Calcium |
| 37 Rb 2,8,18,8,1 Rubidium | 38 Sr 2,8,18,8,2 Strontium |
| 55 Cs 2,8,18,18,8,1 Caesium | 56 Ba 2,8,18,18,8,2 Barium |
| 87 Fr 2,8,18,32,18,8,1 Francium | 88 Ra 2,8,18,32,18,8,2 Radium |

Key

| |
|----------------------|
| Atomic number |
| Symbol |
| Electron arrangement |
| Name |

Transition elements

| | | | | | | | | | |
|---|--|--|---|--|--|---|---|--|--|
| (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
| 21 Sc 2,8,9,2 Scandium | 22 Ti 2,8,10,2 Titanium | 23 V 2,8,11,2 Vanadium | 24 Cr 2,8,13,1 Chromium | 25 Mn 2,8,13,2 Manganese | 26 Fe 2,8,14,2 Iron | 27 Co 2,8,15,2 Cobalt | 28 Ni 2,8,16,2 Nickel | 29 Cu 2,8,18,1 Copper | 30 Zn 2,8,18,2 Zinc |
| 39 Y 2,8,18,9,2 Yttrium | 40 Zr 2,8,18,10,2 Zirconium | 41 Nb 2,8,18,12,1 Niobium | 42 Mo 2,8,18,13,1 Molybdenum | 43 Tc 2,8,18,13,2 Technetium | 44 Ru 2,8,18,15,1 Ruthenium | 45 Rh 2,8,18,16,1 Rhodium | 46 Pd 2,8,18,18,0 Palladium | 47 Ag 2,8,18,18,1 Silver | 48 Cd 2,8,18,18,2 Cadmium |
| 57 La 2,8,18,18,9,2 Lanthanum | 72 Hf 2,8,18,32,10,2 Hafnium | 73 Ta 2,8,18,32,11,2 Tantalum | 74 W 2,8,18,32,12,2 Tungsten | 75 Re 2,8,18,32,13,2 Rhenium | 76 Os 2,8,18,32,14,2 Osmium | 77 Ir 2,8,18,32,15,2 Iridium | 78 Pt 2,8,18,32,17,1 Platinum | 79 Au 2,8,18,32,18,1 Gold | 80 Hg 2,8,18,32,18,2 Mercury |
| 89 Ac 2,8,18,32,18,9,2 Actinium | 104 Rf 2,8,18,32,32,10,2 Rutherfordium | 105 Db 2,8,18,32,32,11,2 Dubnium | 106 Sg 2,8,18,32,32,12,2 Seaborgium | 107 Bh 2,8,18,32,32,13,2 Bohrium | 108 Hs 2,8,18,32,32,14,2 Hassium | 109 Mt 2,8,18,32,32,15,2 Meitnerium | 110 Ds 2,8,18,32,32,17,1 Darmstadtium | 111 Rg 2,8,18,32,32,18,1 Roentgenium | 112 Cn 2,8,18,32,32,18,2 Copernicium |

Group 3 Group 4 Group 5 Group 6 Group 7 Group 0
(18)

| | | | | | |
|---|---|--|---|---|--|
| 5 B 2,3 Boron | 6 C 2,4 Carbon | 7 N 2,5 Nitrogen | 8 O 2,6 Oxygen | 9 F 2,7 Fluorine | 10 Ne 2,8 Neon |
| 13 Al 2,8,3 Aluminium | 14 Si 2,8,4 Silicon | 15 P 2,8,5 Phosphorus | 16 S 2,8,6 Sulfur | 17 Cl 2,8,7 Chlorine | 18 Ar 2,8,8 Argon |
| 31 Ga 2,8,18,3 Gallium | 32 Ge 2,8,18,4 Germanium | 33 As 2,8,18,5 Arsenic | 34 Se 2,8,18,6 Selenium | 35 Br 2,8,18,7 Bromine | 36 Kr 2,8,18,8 Krypton |
| 49 In 2,8,18,18,3 Indium | 50 Sn 2,8,18,18,4 Tin | 51 Sb 2,8,18,18,5 Antimony | 52 Te 2,8,18,18,6 Tellurium | 53 I 2,8,18,18,7 Iodine | 54 Xe 2,8,18,18,8 Xenon |
| 81 Tl 2,8,18,32,18,3 Thallium | 82 Pb 2,8,18,32,18,4 Lead | 83 Bi 2,8,18,32,18,5 Bismuth | 84 Po 2,8,18,32,18,6 Polonium | 85 At 2,8,18,32,18,7 Astatine | 86 Rn 2,8,18,32,18,8 Radon |

Lanthanides

| | | | | | | | | | | | | | | |
|---|--|--|---|--|--|--|--|---|--|---|--|---|---|--|
| 57 La 2,8,18,18,9,2 Lanthanum | 58 Ce 2,8,18,20,8,2 Cerium | 59 Pr 2,8,18,21,8,2 Praseodymium | 60 Nd 2,8,18,22,8,2 Neodymium | 61 Pm 2,8,18,23,8,2 Promethium | 62 Sm 2,8,18,24,8,2 Samarium | 63 Eu 2,8,18,25,8,2 Europium | 64 Gd 2,8,18,25,9,2 Gadolinium | 65 Tb 2,8,18,27,8,2 Terbium | 66 Dy 2,8,18,28,8,2 Dysprosium | 67 Ho 2,8,18,29,8,2 Holmium | 68 Er 2,8,18,30,8,2 Erbium | 69 Tm 2,8,18,31,8,2 Thulium | 70 Yb 2,8,18,32,8,2 Ytterbium | 71 Lu 2,8,18,32,9,2 Lutetium |
|---|--|--|---|--|--|--|--|---|--|---|--|---|---|--|

Actinides

| | | | | | | | | | | | | | | |
|---|---|---|---|--|--|--|---|--|--|--|---|---|--|--|
| 89 Ac 2,8,18,32,18,9,2 Actinium | 90 Th 2,8,18,32,18,10,2 Thorium | 91 Pa 2,8,18,32,20,9,2 Protactinium | 92 U 2,8,18,32,21,9,2 Uranium | 93 Np 2,8,18,32,22,9,2 Neptunium | 94 Pu 2,8,18,32,24,8,2 Plutonium | 95 Am 2,8,18,32,25,8,2 Americium | 96 Cm 2,8,18,32,25,9,2 Curium | 97 Bk 2,8,18,32,27,8,2 Berkelium | 98 Cf 2,8,18,32,28,8,2 Californium | 99 Es 2,8,18,32,29,8,2 Einsteinium | 100 Fm 2,8,18,32,30,8,2 Fermium | 101 Md 2,8,18,32,31,8,2 Mendelevium | 102 No 2,8,18,32,32,8,2 Nobelium | 103 Lr 2,8,18,32,32,9,2 Lawrencium |
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