National Qualifications 2025

X857/77/11

# Physics
# Relationships sheet

THURSDAY, 15 MAY
9:00 AM – 12:00 NOON

**Relationships required for Physics Advanced Higher**

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

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

$$v = u + at$$

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

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

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

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

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

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

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

$$s = r\theta$$

$$v = r\omega$$

$$a_t = r\alpha$$

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

$$\omega = 2\pi f$$

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

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

$$I = \sum mr^2$$

$$\tau = Fr$$

$$\tau = I\alpha$$

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

$$L = I\omega$$

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

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

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

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

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

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

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

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

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

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

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

$$E = hf$$

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

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

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

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

$$F = qvB$$

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

$$F = -ky$$

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

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

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

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

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

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

$$E = kA^2$$

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

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

$$opd = n \times gpd$$

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

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

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

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

$$n = \tan i_P$$

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

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

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

$$F = QE$$

$$V = Ed$$

$$W = QV$$

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

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

$$F = IlB\sin\theta$$

$$F = qvB$$

$$\tau = RC$$

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

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

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

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

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

$$X_L = 2\pi fL$$

$$c = \frac{1}{\sqrt{\varepsilon_o\mu_o}}$$

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

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

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

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

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

$$v = u + at$$

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

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

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

$$W = mg$$

$$F = ma$$

$$E_W = Fd$$

$$E_P = mgh$$

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

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

$$p = mv$$

$$Ft = mv - mu$$

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

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

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

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

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

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

$$v = H_0 d$$

$$W = QV$$

$$E = mc^2$$

$$E = hf$$

$$E_K = hf - hf_0$$

$$E_2 - E_1 = hf$$

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

$$v = f\lambda$$

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

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

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

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

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

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

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

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

$$Q = It$$

$$V = IR$$

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

$$R_T = R_1 + R_2 + \ldots$$

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

$$E = V + Ir$$

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

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

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

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

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

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

## Additional relationships

### Circle

circumference $= 2\pi r$

area $= \pi r^2$

### Sphere

area $= 4\pi r^2$

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

**Key**

Atomic number
Symbol
Electron arrangement
Name

## Transition elements

| Group 1 (1) | Group 2 (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | Group 3 (13) | Group 4 (14) | Group 5 (15) | Group 6 (16) | Group 7 (17) | Group 0 (18) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 **H** 1 Hydrogen | | | | | | | | | | | | | | | | | 2 **He** 2 Helium |
| 3 **Li** 2,1 Lithium | 4 **Be** 2,2 Beryllium | | | | | | | | | | | 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 |
| 11 **Na** 2,8,1 Sodium | 12 **Mg** 2,8,2 Magnesium | | | | | | | | | | | 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 |
| 19 **K** 2,8,8,1 Potassium | 20 **Ca** 2,8,8,2 Calcium | 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 | 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 |
| 37 **Rb** 2,8,18,8,1 Rubidium | 38 **Sr** 2,8,18,8,2 Strontium | 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 | 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 |
| 55 **Cs** 2,8,18,18, 8,1 Caesium | 56 **Ba** 2,8,18,18, 8,2 Barium | 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 | 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 |
| 87 **Fr** 2,8,18,32, 18,8,1 Francium | 88 **Ra** 2,8,18,32, 18,8,2 Radium | 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 | | | | | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **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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