AH

National
Qualifications
2022

X857/77/11

**Physics
Relationships sheet**

FRIDAY, 13 MAY
9:00 AM – 12:00 NOON

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Relationships required for Physics Advanced Higher

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

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

$$v = u + at$$

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

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

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

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

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

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

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

$$s = r\theta$$

$$v = r\omega$$

$$a_t = r\alpha$$

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

$$\omega = 2\pi f$$

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

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

$$I = \sum mr^2$$

$$\tau = Fr$$

$$\tau = I\alpha$$

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

$$L = I\omega$$

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

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

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

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

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

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

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

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

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

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

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

$$E = hf$$

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

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

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

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

$$F = qvB$$

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

$$F = -ky$$

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

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

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

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

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

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

$$E = kA^2$$

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

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

$$opd = n \times gpd$$

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

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

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

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

$$n = \tan i_P$$

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

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

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

$$F = QE$$

$$V = Ed$$

$$W = QV$$

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

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

$$F = IlB\sin\theta$$

$$F = qvB$$

$$\tau = RC$$

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

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

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

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

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

$$X_L = 2\pi fL$$

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

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

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

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

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

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

$$v = u + at$$

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

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

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

$$W = mg$$

$$F = ma$$

$$E_W = Fd$$

$$E_P = mgh$$

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

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

$$p = mv$$

$$Ft = mv - mu$$

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

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

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

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

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

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

$$v = H_0 d$$

$$W = QV$$

$$E = mc^2$$

$$E = hf$$

$$E_K = hf - hf_0$$

$$E_2 - E_1 = hf$$

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

$$v = f\lambda$$

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

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

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

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

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

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

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

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

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

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

$$Q = It$$

$$V = IR$$

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

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

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

$$E = V + Ir$$

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

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

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

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

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

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

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

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

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

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

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

Electron arrangements of elements

Key

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

Transition elements

Group 1 (1)	Group 2 (2)													Group 3 (13)	Group 4 (14)	Group 5 (15)	Group 6 (16)	Group 7 (17)	Group 0 (18)
1 **H** Hydrogen 1																			2 **He** Helium 2
3 **Li** Lithium 2,1	4 **Be** Beryllium 2,2													5 **B** Boron 2,3	6 **C** Carbon 2,4	7 **N** Nitrogen 2,5	8 **O** Oxygen 2,6	9 **F** Fluorine 2,7	10 **Ne** Neon 2,8
11 **Na** Sodium 2,8,1	12 **Mg** Magnesium 2,8,2	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)			13 **Al** Aluminium 2,8,3	14 **Si** Silicon 2,8,4	15 **P** Phosphorus 2,8,5	16 **S** Sulfur 2,8,6	17 **Cl** Chlorine 2,8,7	18 **Ar** Argon 2,8,8
19 **K** Potassium 2,8,8,1	20 **Ca** Calcium 2,8,8,2	21 **Sc** Scandium 2,8,9,2	22 **Ti** Titanium 2,8,10,2	23 **V** Vanadium 2,8,11,2	24 **Cr** Chromium 2,8,13,1	25 **Mn** Manganese 2,8,13,2	26 **Fe** Iron 2,8,14,2	27 **Co** Cobalt 2,8,15,2	28 **Ni** Nickel 2,8,16,2	29 **Cu** Copper 2,8,18,1	30 **Zn** Zinc 2,8,18,2			31 **Ga** Gallium 2,8,18,3	32 **Ge** Germanium 2,8,18,4	33 **As** Arsenic 2,8,18,5	34 **Se** Selenium 2,8,18,6	35 **Br** Bromine 2,8,18,7	36 **Kr** Krypton 2,8,18,8
37 **Rb** Rubidium 2,8,18,8,1	38 **Sr** Strontium 2,8,18,8,2	39 **Y** Yttrium 2,8,18,9,2	40 **Zr** Zirconium 2,8,18,10,2	41 **Nb** Niobium 2,8,18,12,1	42 **Mo** Molybdenum 2,8,18,13,1	43 **Tc** Technetium 2,8,18,13,2	44 **Ru** Ruthenium 2,8,18,15,1	45 **Rh** Rhodium 2,8,18,16,1	46 **Pd** Palladium 2,8,18,18,0	47 **Ag** Silver 2,8,18,18,1	48 **Cd** Cadmium 2,8,18,18,2			49 **In** Indium 2,8,18,18,3	50 **Sn** Tin 2,8,18,18,4	51 **Sb** Antimony 2,8,18,18,5	52 **Te** Tellurium 2,8,18,18,6	53 **I** Iodine 2,8,18,18,7	54 **Xe** Xenon 2,8,18,18,8
55 **Cs** Caesium 2,8,18,18,8,1	56 **Ba** Barium 2,8,18,18,8,2	57 **La** Lanthanum 2,8,18,18,9,2	72 **Hf** Hafnium 2,8,18,32,10,2	73 **Ta** Tantalum 2,8,18,32,11,2	74 **W** Tungsten 2,8,18,32,12,2	75 **Re** Rhenium 2,8,18,32,13,2	76 **Os** Osmium 2,8,18,32,14,2	77 **Ir** Iridium 2,8,18,32,15,2	78 **Pt** Platinum 2,8,18,32,17,1	79 **Au** Gold 2,8,18,32,18,1	80 **Hg** Mercury 2,8,18,32,18,2			81 **Tl** Thallium 2,8,18,32,18,3	82 **Pb** Lead 2,8,18,32,18,4	83 **Bi** Bismuth 2,8,18,32,18,5	84 **Po** Polonium 2,8,18,32,18,6	85 **At** Astatine 2,8,18,32,18,7	86 **Rn** Radon 2,8,18,32,18,8
87 **Fr** Francium 2,8,18,32,18,8,1	88 **Ra** Radium 2,8,18,32,18,8,2	89 **Ac** Actinium 2,8,18,32,18,9,2	104 **Rf** Rutherfordium 2,8,18,32,32,10,2	105 **Db** Dubnium 2,8,18,32,32,11,2	106 **Sg** Seaborgium 2,8,18,32,32,12,2	107 **Bh** Bohrium 2,8,18,32,32,13,2	108 **Hs** Hassium 2,8,18,32,32,14,2	109 **Mt** Meitnerium 2,8,18,32,32,15,2	110 **Ds** Darmstadtium 2,8,18,32,32,17,1	111 **Rg** Roentgenium 2,8,18,32,32,18,1	112 **Cn** Copernicium 2,8,18,32,32,18,2								

Lanthanides

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

Actinides

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

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