



National  
Qualifications  
2023

**X857/77/11**

**Physics  
Relationships sheet**

WEDNESDAY, 17 MAY  
9:00 AM – 12:00 NOON

---



## Relationships required for Physics Advanced Higher

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

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

$$v = u + at$$

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

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

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

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

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

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

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

$$s = r\theta$$

$$v = r\omega$$

$$a_t = r\alpha$$

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

$$\omega = 2\pi f$$

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

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

$$I = \sum mr^2$$

$$\tau = Fr$$

$$\tau = I\alpha$$

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

$$L = I\omega$$

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

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

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

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

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

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

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

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

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

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

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

$$E = hf$$

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

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

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

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

$$F = qvB$$

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

$$F = -ky$$

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

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

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

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

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

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

$$E = kA^2$$

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

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

$$opd = n \times gpd$$

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

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

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

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

$$n = \tan i_p$$

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

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

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

$$F = QE$$

$$V = Ed$$

$$W = QV$$

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

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

$$F = IlB \sin \theta$$

$$F = qvB$$

$$\tau = RC$$

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

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

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

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

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

$$X_L = 2\pi fL$$

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

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

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

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

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

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

$$v = u + at$$

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

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

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

$$W = mg$$

$$F = ma$$

$$E_W = Fd$$

$$E_P = mgh$$

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

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

$$p = mv$$

$$Ft = mv - mu$$

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

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

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

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

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

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

$$v = H_0 d$$

$$W = QV$$

$$E = mc^2$$

$$E = hf$$

$$E_K = hf - hf_0$$

$$E_2 - E_1 = hf$$

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

$$v = f\lambda$$

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

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

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

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

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

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

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

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

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

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

$$Q = It$$

$$V = IR$$

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

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

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

$$E = V + Ir$$

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

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

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

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

## 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 <b>H</b>	4 <b>Be</b>
1 <b>Hydrogen</b>	(2)
3 <b>Li</b> 2,1	2,2 <b>B</b>
Lithium	Beryllium
11 <b>Na</b> 2,8,1	12 <b>Mg</b> 2,8,2
Sodium	Magnesium
19 <b>K</b> 2,8,8,1	20 <b>Ca</b> 2,8,8,2
Potassium	Calcium
37 <b>Rb</b> 2,8,18,8,1	38 <b>Sr</b> 2,8,18,8,2
Rubidium	Strontium
55 <b>Cs</b> 2,8,18,18,8,1	56 <b>Ba</b> 2,8,18,18,8,2
Cesium	Barium
87 <b>Fr</b> 2,8,18,32,18,8,1	88 <b>Ra</b> 2,8,18,32,18,8,2
Francium	Radium

## Key

Atomic number
Symbol
Electron arrangement
Name

## Transition elements

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

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

Group 3      Group 4      Group 5      Group 6      Group 7      Group 0

(18)

57 <b>La</b> 2,8,18,18,9,2	58 <b>Ce</b> 2,8,18,20,8,2	59 <b>Pr</b> 2,8,18,21,8,2	60 <b>Nd</b> 2,8,18,22,8,2	61 <b>Pm</b> 2,8,18,23,8,2	62 <b>Sm</b> 2,8,18,24,8,2	63 <b>Eu</b> 2,8,18,25,8,2	64 <b>Gd</b> 2,8,18,25,9,2	65 <b>Tb</b> 2,8,18,27,8,2	66 <b>Dy</b> 2,8,18,28,8,2	67 <b>Ho</b> 2,8,18,29,8,2	68 <b>Er</b> 2,8,18,30,8,2	69 <b>Tm</b> 2,8,18,31,8,2	70 <b>Yb</b> 2,8,18,32,8,2	71 <b>Lu</b> 2,8,18,32,9,2
Lanthanum	Cerium	Praseodymium	Neodymium	Promethium	Samarium	Europium	Gadolinium	Terbium	Dysprosium	Holmium	Erbium	Thulium	Ytterbium	Lutetium
89 <b>Ac</b> 2,8,18,32,18,9,2	90 <b>Th</b> 2,8,18,32,18,10,2	91 <b>Pa</b> 2,8,18,32,20,9,2	92 <b>U</b> 2,8,18,32,21,9,2	93 <b>Np</b> 2,8,18,32,22,9,2	94 <b>Pu</b> 2,8,18,32,24,8,2	95 <b>Am</b> 2,8,18,32,25,8,2	96 <b>Cm</b> 2,8,18,32,25,9,2	97 <b>Bk</b> 2,8,18,32,27,8,2	98 <b>Cf</b> 2,8,18,32,28,8,2	99 <b>Es</b> 2,8,18,32,29,8,2	100 <b>Fm</b> 2,8,18,32,30,8,2	101 <b>Md</b> 2,8,18,32,31,8,2	102 <b>No</b> 2,8,18,32,32,8,2	103 <b>Lr</b> 2,8,18,32,32,9,2
Actinium	Thorium	Protactinium	Uranium	Neptunium	Plutonium	Americium	Curium	Berkelium	Californium	Einsteinium	Fermium	Mendelevium	Nobelium	Lawrencium

## Lanthanides

## Actinides

[BLANK PAGE]

DO NOT WRITE ON THIS PAGE

[BLANK PAGE]

DO NOT WRITE ON THIS PAGE