



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	H	
1		
Hydrogen	(2)	

3	Li	4
2,1		Be
Lithium		Beryllium

11	Na	12
2,8,1		Mg
Sodium		Magnesium

19	K	20
2,8,8,1		Ca
Potassium		Calcium

37	Rb	38
2,8,18,8,1		Sr
Rubidium		Strontium

55	Cs	56
2,8,18,18,8,1		Ba
Cæsium		Barium

87	Fr	88
2,8,18,32,18,8,1		Ra
Francium		Radium

Key

Atomic number
Symbol
Electron arrangement
Name

Transition elements

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

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

2	He	
2		
Helium		

5	6	7	8	9	10
B	C	N	O	F	Ne
2,3	2,4	2,5	2,6	2,7	2,8
Boron	Carbon	Nitrogen	Oxygen	Fluorine	Neon

13	14	15	16	17	18
Al	Si	P	S	Cl	Ar
2,8,3	2,8,4	2,8,5	2,8,6	2,8,7	2,8,8
Aluminium	Silicon	Phosphorus	Sulphur	Chlorine	Argon

31	32	33	34	35	36
Ga	Ge	As	Se	Br	Kr
2,8,18,3	2,8,18,4	2,8,18,5	2,8,18,6	2,8,18,7	2,8,18,8
Gallium	Germanium	Arsenic	Selenium	Bromine	Krypton

49	50	51	52	53	54
In	Sn	Sb	Te	I	Xe
2,8,18,18,3	2,8,18,18,4	2,8,18,18,5	2,8,18,18,6	2,8,18,18,7	2,8,18,18,8
Indium	Tin	Antimony	Tellurium	Iodine	Xenon

81	82	83	84	85	86
Tl	Pb	Bi	Po	At	Rn
2,8,18,32,18,3	2,8,18,32,18,4	2,8,18,32,18,5	2,8,18,32,18,6	2,8,18,32,18,7	2,8,18,32,18,8
Thallium	Lead	Bismuth	Polonium	Astatine	Radon

Lanthanides

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

Actinides

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

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