



National
Qualifications
2023

X857/77/11

**Physics
Relationships sheet**

WEDNESDAY, 17 MAY

9:00 AM – 12:00 NOON



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Relationships required for Physics Advanced Higher

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

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

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

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

$$v = u + at$$

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

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

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

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

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

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

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

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

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

$$\omega = \omega_o + at$$

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

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

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

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

$$s = r\theta$$

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

$$a_t = r\alpha$$

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

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

$$E = hf$$

$$\omega = 2\pi f$$

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

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

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

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

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

$$I = \sum mr^2$$

$$\tau = Fr$$

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

$$\tau = I\alpha$$

$$F = qvB$$

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

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

$$L = I\omega$$

$$F = -ky$$

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

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

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

$$F = QE$$

$$V = Ed$$

$$W = QV$$

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

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

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

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

$$F = IlB \sin \theta$$

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

$$F = qvB$$

$$E = kA^2$$

$$\tau = RC$$

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

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

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

$$X_C = \frac{1}{2\pi f C}$$

$$opd = n \times gpd$$

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

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

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

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

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

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

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

$$X_L = 2\pi f L$$

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

$$n = \tan i_P$$

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

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

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

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

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

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

$d = \bar{v}t$	$W = QV$	$V_{peak} = \sqrt{2}V_{rms}$
$s = \bar{v}t$	$E = mc^2$	$I_{peak} = \sqrt{2}I_{rms}$
$v = u + at$	$E = hf$	$Q = It$
$s = ut + \frac{1}{2}at^2$	$E_K = hf - hf_0$	$V = IR$
$v^2 = u^2 + 2as$	$E_2 - E_1 = hf$	$P = IV = I^2R = \frac{V^2}{R}$
$s = \frac{1}{2}(u+v)t$	$T = \frac{1}{f}$	$R_T = R_1 + R_2 + \dots$
$W = mg$	$v = f\lambda$	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$
$F = ma$	$d \sin \theta = m\lambda$	$E = V + Ir$
$E_W = Fd$	$n = \frac{\sin \theta_1}{\sin \theta_2}$	$V_1 = \left(\frac{R_1}{R_1 + R_2} \right) V_S$
$E_P = mgh$	$\frac{\sin \theta_1}{\sin \theta_2} = \frac{\lambda_1}{\lambda_2} = \frac{v_1}{v_2}$	$\frac{V_1}{V_2} = \frac{R_1}{R_2}$
$E_K = \frac{1}{2}mv^2$	$\sin \theta_c = \frac{1}{n}$	$C = \frac{Q}{V}$
$P = \frac{E}{t}$	$I = \frac{k}{d^2}$	$E = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$
$p = mv$	$I = \frac{P}{A}$	path difference = $m\lambda$ or $\left(m + \frac{1}{2}\right)\lambda$ where $m = 0, 1, 2, \dots$
$Ft = mv - mu$	random uncertainty = $\frac{\text{max. value} - \text{min. value}}{\text{number of values}}$	
$F = G \frac{Mm}{r^2}$		
$t' = \frac{t}{\sqrt{1 - \left(\frac{v}{c}\right)^2}}$		
$l' = l\sqrt{1 - \left(\frac{v}{c}\right)^2}$		
$f_o = f_s \left(\frac{v}{v \pm v_s} \right)$		
$z = \frac{\lambda_{observed} - \lambda_{rest}}{\lambda_{rest}}$		
$z = \frac{v}{c}$		
$v = H_0 d$		

Additional relationships

Circle

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

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

Sphere

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

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

Table of standard derivatives

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

Trigonometry

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

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

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

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

Table of standard integrals

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

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

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

Electron arrangements of elements

		Group 1		Group 2		Group 3		Group 4		Group 5		Group 6		Group 7		Group 0	
		(1)		(2)													
1	H	1	Hydrogen	3	Li	4	Be	2,1	2,2	2,1	Lithium	11	Na	12	Mg	2,8,1	Beryllium
2				2				2,8,1	2,8,2	2	Sodium	19	K	20	Mg	2,8,1	Magnesium
3				3				2,8,8,1	2,8,8,2	3	Potassium	21	Sc	22	Ti	2,8,9,2	Calcium
4				4				2,8,8,1	2,8,8,2	4	Scandium	23	V	24	Cr	2,8,9,2	Titanium
5				5				2,8,8,1	2,8,8,2	5	Chromium	25	Mn	26	Fe	2,8,9,2	Vanadium
6				6				2,8,8,1	2,8,8,2	6	Manganese	27	Ni	28	Cu	2,8,9,2	Chromium
7				7				2,8,8,1	2,8,8,2	7	Iron	29	Zn	30	Zn	2,8,9,2	Manganese
8				8				2,8,8,1	2,8,8,2	8	Cobalt	31	Ga	32	Ge	2,8,9,2	Iron
9				9				2,8,8,1	2,8,8,2	9	Nickel	33	As	34	Se	2,8,9,2	Cobalt
10				10				2,8,8,1	2,8,8,2	10	P	35	Br	36	Kr	2,8,9,2	Nickel
11				11				2,8,8,1	2,8,8,2	11	S	37	Cl	38	Ar	2,8,9,2	P
12				12				2,8,8,1	2,8,8,2	12	Oxygen	39	F	40	Ne	2,8,9,2	Cl
13				13				2,8,8,1	2,8,8,2	13	Fluorine	41	Boron	42	Al	2,8,9,2	Oxygen
14				14				2,8,8,1	2,8,8,2	14	Neon	43	Si	44	Si	2,8,9,2	Fluorine
15				15				2,8,8,1	2,8,8,2	15	Argon	45	B	46	He	2,8,9,2	Neon
16				16				2,8,8,1	2,8,8,2	16	Chlorine	47	C	48	H	2,8,9,2	Argon
17				17				2,8,8,1	2,8,8,2	17	Chlorine	49	Al	50	Al	2,8,9,2	H
18				18				2,8,8,1	2,8,8,2	18	Phosphorus	51	Si	52	Si	2,8,9,2	Al
19				19				2,8,8,1	2,8,8,2	19	Sulfur	53	Ge	54	Ge	2,8,9,2	Si
20				20				2,8,8,1	2,8,8,2	20	Sulfur	55	Sc	56	Sc	2,8,9,2	Ge
21				21				2,8,8,1	2,8,8,2	21	Phosphorus	57	Ca	58	Ca	2,8,9,2	Sc
22				22				2,8,8,1	2,8,8,2	22	Sulfur	59	Cr	60	Cr	2,8,9,2	Ca
23				23				2,8,8,1	2,8,8,2	23	Phosphorus	61	Fe	62	Fe	2,8,9,2	Cr
24				24				2,8,8,1	2,8,8,2	24	Sulfur	63	Ni	64	Ni	2,8,9,2	Fe
25				25				2,8,8,1	2,8,8,2	25	Phosphorus	65	Co	66	Co	2,8,9,2	Ni
26				26				2,8,8,1	2,8,8,2	26	Sulfur	67	Mo	68	Mo	2,8,9,2	Co
27				27				2,8,8,1	2,8,8,2	27	Phosphorus	69	Tm	70	Tm	2,8,9,2	Mo
28				28				2,8,8,1	2,8,8,2	28	Sulfur	71	Yb	72	Yb	2,8,9,2	Tm
29				29				2,8,8,1	2,8,8,2	29	Phosphorus	73	Lu	74	Lu	2,8,9,2	Yb
30				30				2,8,8,1	2,8,8,2	30	Sulfur	75	He	76	He	2,8,9,2	Lu
31				31				2,8,8,1	2,8,8,2	31	Phosphorus	77	Fr	78	Fr	2,8,9,2	He
32				32				2,8,8,1	2,8,8,2	32	Sulfur	79	Rb	80	Rb	2,8,9,2	Fr
33				33				2,8,8,1	2,8,8,2	33	Phosphorus	81	Ca	82	Ca	2,8,9,2	Rb
34				34				2,8,8,1	2,8,8,2	34	Sulfur	83	Sc	84	Sc	2,8,9,2	Ca
35				35				2,8,8,1	2,8,8,2	35	Phosphorus	85	Cr	86	Cr	2,8,9,2	Sc
36				36				2,8,8,1	2,8,8,2	36	Sulfur	87	Fe	88	Fe	2,8,9,2	Cr
37				37				2,8,8,1	2,8,8,2	37	Phosphorus	89	Co	90	Co	2,8,9,2	Fe
38				38				2,8,8,1	2,8,8,2	38	Sulfur	91	Cr	92	Cr	2,8,9,2	Co
39				39				2,8,8,1	2,8,8,2	39	Phosphorus	93	Fe	94	Fe	2,8,9,2	Cr
40				40				2,8,8,1	2,8,8,2	40	Sulfur	95	Co	96	Co	2,8,9,2	Fe
41				41				2,8,8,1	2,8,8,2	41	Phosphorus	97	Fe	98	Fe	2,8,9,2	Co
42				42				2,8,8,1	2,8,8,2	42	Sulfur	99	Cr	100	Cr	2,8,9,2	Fe
43				43				2,8,8,1	2,8,8,2	43	Phosphorus	101	Fe	102	Fe	2,8,9,2	Cr
44				44				2,8,8,1	2,8,8,2	44	Sulfur	103	Cr	104	Cr	2,8,9,2	Fe
45				45				2,8,8,1	2,8,8,2	45	Phosphorus	105	Fe	106	Fe	2,8,9,2	Cr
46				46				2,8,8,1	2,8,8,2	46	Sulfur	107	Cr	108	Cr	2,8,9,2	Fe
47				47				2,8,8,1	2,8,8,2	47	Phosphorus	109	Fe	110	Fe	2,8,9,2	Cr
48				48				2,8,8,1	2,8,8,2	48	Sulfur	111	Cr	112	Cr	2,8,9,2	Fe
49				49				2,8,8,1	2,8,8,2	49	Phosphorus	113	Fe	114	Fe	2,8,9,2	Cr
50				50				2,8,8,1	2,8,8,2	50	Sulfur	115	Cr	116	Cr	2,8,9,2	Fe
51				51				2,8,8,1	2,8,8,2	51	Phosphorus	117	Fe	118	Fe	2,8,9,2	Cr
52				52				2,8,8,1	2,8,8,2	52	Sulfur	119	Cr	120	Cr	2,8,9,2	Fe
53				53				2,8,8,1	2,8,8,2	53	Phosphorus	121	Fe	122	Fe	2,8,9,2	Cr
54				54				2,8,8,1	2,8,8,2	54	Sulfur	123	Cr	124	Cr	2,8,9,2	Fe
55				55				2,8,8,1	2,8,8,2	55	Phosphorus	125	Fe	126	Fe	2,8,9,2	Cr
56				56				2,8,8,1	2,8,8,2	56	Sulfur	127	Cr	128	Cr	2,8,9,2	Fe
57				57				2,8,8,1	2,8,8,2	57	Phosphorus	129	Fe	130	Fe	2,8,9,2	Cr
58				58				2,8,8,1	2,8,8,2	58	Sulfur	131	Cr	132	Cr	2,8,9,2	Fe
59				59				2,8,8,1	2,8,8,2	59	Phosphorus	133	Fe	134	Fe	2,8,9,2	Cr
60				60				2,8,8,1	2,8,8,2	60	Sulfur	135	Cr	136	Cr	2,8,9,2	Fe
61				61				2,8,8,1	2,8,8,2	61	Phosphorus	137	Fe	138	Fe	2,8,9,2	Cr
62				62				2,8,8,1	2,8,8,2	62	Sulfur	139	Cr	140	Cr	2,8,9,2	Fe
63				63				2,8,8,1	2,8,8,2	63	Phosphorus	141	Fe	142	Fe	2,8,9,2	Cr
64				64				2,8,8,1	2,8,8,2	64	Sulfur	143	Cr	144	Cr	2,8,9,2	Fe
65				65				2,8,8,1	2,8,8,2	65	Phosphorus	145	Fe	146	Fe	2,8,9,2	Cr
66				66				2,8,8,1	2,8,8,2	66	Sulfur	147	Cr	148	Cr	2,8,9,2	Fe
67				67				2,8,8,1	2,8,8,2	67	Phosphorus	149	Fe	150	Fe	2,8,9,2	Cr
68				68				2,8,8,1	2,8,8,2	68	Sulfur	151	Cr	152	Cr	2,8,9,2	Fe
69				69				2,8,8,1	2,8,8,2	69	Phosphorus	153	Fe	154	Fe	2,8,9,2	Cr
70				70				2,8,8,1	2,8,8,2	70	Sulfur	155	Cr	156	Cr	2,8,9,2	Fe
71				71				2,8,8,1	2,8,8,2	71	Phosphorus	157	Fe	158	Fe	2,8,9,2	Cr
72				72				2,8,8,1	2,8,8,2	72	Sulfur	159	Cr	160	Cr	2,8,9,2	Fe
73				73				2,8,8,1	2,8,8,2	73	Phosphorus	161	Fe	162	Fe	2,8,9,2	Cr
74				74				2,8,8,1	2,8,8,2	74	Sulfur	163	Cr	164	Cr	2,8,9,2	Fe
75				75				2,8,8,1	2,8,8,2	75	Phosphorus	165	Fe	166	Fe	2,8,9,2	Cr
76				76				2,8,8,1	2,8,8,2	76	Sulfur	167	Cr	168	Cr	2,8,9,2	Fe
77				77				2,8,8,1	2,8,8,2	77	Phosphorus	169	Fe	170	Fe	2,8,9,2	Cr
78				78				2,8,8,1	2,8,8,2	78	Sulfur	171	Cr	172	Cr	2,8,9,2	Fe
79				79				2,8,8,1	2,8,8,2	79	Phosphorus	173	Fe	174	Fe	2,8,9,2	Cr
80				80				2,8,8,1	2,8,8,2	80	Sulfur	175	Cr	176	Cr	2,8,9,2	Fe
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