AH
National Qualifications 2023

X857/77/11

Physics Relationships sheet

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

Relationships required for Physics Advanced Higher

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

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

$$v = u + at$$

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

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

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

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

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

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

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

$$s = r\theta$$

$$v = r\omega$$

$$a_t = r\alpha$$

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

$$\omega = 2\pi f$$

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

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

$$I = \sum mr^2$$

$$\tau = Fr$$

$$\tau = I\alpha$$

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

$$L = I\omega$$

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

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

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

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

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

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

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

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

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

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

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

$$E = hf$$

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

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

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

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

$$F = qvB$$

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

$$F = -ky$$

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

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

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

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

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

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

$$E = kA^2$$

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

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

$$opd = n \times gpd$$

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

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

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

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

$$n = \tan i_P$$

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

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

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

$$F = QE$$

$$V = Ed$$

$$W = QV$$

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

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

$$F = IlB\sin\theta$$

$$F = qvB$$

$$\tau = RC$$

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

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

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

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

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

$$X_L = 2\pi fL$$

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

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

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

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

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

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

$$v = u + at$$

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

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

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

$$W = mg$$

$$F = ma$$

$$E_W = Fd$$

$$E_P = mgh$$

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

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

$$p = mv$$

$$Ft = mv - mu$$

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

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

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

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

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

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

$$v = H_0 d$$

$$W = QV$$

$$E = mc^2$$

$$E = hf$$

$$E_K = hf - hf_0$$

$$E_2 - E_1 = hf$$

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

$$v = f\lambda$$

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

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

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

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

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

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

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

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

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

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

$$Q = It$$

$$V = IR$$

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

$$R_T = R_1 + R_2 + ...$$

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

$$E = V + Ir$$

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

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

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

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

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 **H** Hydrogen (1)
- 3 **Li** 2,1 Lithium
- 11 **Na** 2,8,1 Sodium
- 19 **K** 2,8,8,1 Potassium
- 37 **Rb** 2,8,18,8,1 Rubidium
- 55 **Cs** 2,8,18,18,8,1 Caesium
- 87 **Fr** 2,8,18,32,18,8,1 Francium

Group 2 (2)
- 4 **Be** 2,2 Beryllium
- 12 **Mg** 2,8,2 Magnesium
- 20 **Ca** 2,8,8,2 Calcium
- 38 **Sr** 2,8,18,8,2 Strontium
- 56 **Ba** 2,8,18,18,8,2 Barium
- 88 **Ra** 2,8,18,32,18,8,2 Radium

(3)
- 21 **Sc** 2,8,9,2 Scandium
- 39 **Y** 2,8,18,9,2 Yttrium
- 57 **La** 2,8,18,18,9,2 Lanthanum
- 89 **Ac** 2,8,18,32,18,9,2 Actinium

(4)
- 22 **Ti** 2,8,10,2 Titanium
- 40 **Zr** 2,8,18,10,2 Zirconium
- 72 **Hf** 2,8,18,32,10,2 Hafnium
- 104 **Rf** 2,8,18,32,32,10,2 Rutherfordium

(5)
- 23 **V** 2,8,11,2 Vanadium
- 41 **Nb** 2,8,18,12,1 Niobium
- 73 **Ta** 2,8,18,32,11,2 Tantalum
- 105 **Db** 2,8,18,32,32,11,2 Dubnium

(6)
- 24 **Cr** 2,8,13,1 Chromium
- 42 **Mo** 2,8,18,13,1 Molybdenum
- 74 **W** 2,8,18,32,12,2 Tungsten
- 106 **Sg** 2,8,18,32,32,12,2 Seaborgium

(7)
- 25 **Mn** 2,8,13,2 Manganese
- 43 **Tc** 2,8,18,13,2 Technetium
- 75 **Re** 2,8,18,32,13,2 Rhenium
- 107 **Bh** 2,8,18,32,32,13,2 Bohrium

(8)
- 26 **Fe** 2,8,14,2 Iron
- 44 **Ru** 2,8,18,15,1 Ruthenium
- 76 **Os** 2,8,18,32,14,2 Osmium
- 108 **Hs** 2,8,18,32,32,14,2 Hassium

(9)
- 27 **Co** 2,8,15,2 Cobalt
- 45 **Rh** 2,8,18,16,1 Rhodium
- 77 **Ir** 2,8,18,32,15,2 Iridium
- 109 **Mt** 2,8,18,32,32,15,2 Meitnerium

(10)
- 28 **Ni** 2,8,16,2 Nickel
- 46 **Pd** 2,8,18,18,0 Palladium
- 78 **Pt** 2,8,18,32,17,1 Platinum
- 110 **Ds** 2,8,18,32,32,17,1 Darmstadtium

(11)
- 29 **Cu** 2,8,18,1 Copper
- 47 **Ag** 2,8,18,18,1 Silver
- 79 **Au** 2,8,18,32,18,1 Gold
- 111 **Rg** 2,8,18,32,32,18,1 Roentgenium

(12)
- 30 **Zn** 2,8,18,2 Zinc
- 48 **Cd** 2,8,18,18,2 Cadmium
- 80 **Hg** 2,8,18,32,18,2 Mercury
- 112 **Cn** 2,8,18,32,32,18,2 Copernicium

Group 3 (13)
- 5 **B** 2,3 Boron
- 13 **Al** 2,8,3 Aluminium
- 31 **Ga** 2,8,18,3 Gallium
- 49 **In** 2,8,18,18,3 Indium
- 81 **Tl** 2,8,18,32,18,3 Thallium

Group 4 (14)
- 6 **C** 2,4 Carbon
- 14 **Si** 2,8,4 Silicon
- 32 **Ge** 2,8,18,4 Germanium
- 50 **Sn** 2,8,18,18,4 Tin
- 82 **Pb** 2,8,18,32,18,4 Lead

Group 5 (15)
- 7 **N** 2,5 Nitrogen
- 15 **P** 2,8,5 Phosphorus
- 33 **As** 2,8,18,5 Arsenic
- 51 **Sb** 2,8,18,18,5 Antimony
- 83 **Bi** 2,8,18,32,18,5 Bismuth

Group 6 (16)
- 8 **O** 2,6 Oxygen
- 16 **S** 2,8,6 Sulfur
- 34 **Se** 2,8,18,6 Selenium
- 52 **Te** 2,8,18,18,6 Tellurium
- 84 **Po** 2,8,18,32,18,6 Polonium

Group 7 (17)
- 9 **F** 2,7 Fluorine
- 17 **Cl** 2,8,7 Chlorine
- 35 **Br** 2,8,18,7 Bromine
- 53 **I** 2,8,18,18,7 Iodine
- 85 **At** 2,8,18,32,18,7 Astatine

Group 0 (18)
- 2 **He** 2 Helium
- 10 **Ne** 2,8 Neon
- 18 **Ar** 2,8,8 Argon
- 36 **Kr** 2,8,18,8 Krypton
- 54 **Xe** 2,8,18,18,8 Xenon
- 86 **Rn** 2,8,18,32,18,8 Radon

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

[BLANK PAGE]

DO NOT WRITE ON THIS PAGE

[BLANK PAGE]

DO NOT WRITE ON THIS PAGE