



National  
Qualifications  
2022

**X857/77/11**

**Physics  
Relationships sheet**

FRIDAY, 13 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> |  |
| 1        |          |  |
| Hydrogen | (2)      |  |

|         |           |           |
|---------|-----------|-----------|
| 3       | <b>Li</b> | 4         |
| 2,1     |           | <b>Be</b> |
| Lithium |           | Beryllium |

|        |           |           |
|--------|-----------|-----------|
| 11     | <b>Na</b> | 12        |
| 2,8,1  |           | <b>Mg</b> |
| Sodium |           | Magnesium |

|           |          |           |
|-----------|----------|-----------|
| 19        | <b>K</b> | 20        |
| 2,8,8,1   |          | <b>Ca</b> |
| Potassium |          | Calcium   |

|            |           |           |
|------------|-----------|-----------|
| 37         | <b>Rb</b> | 38        |
| 2,8,18,8,1 |           | <b>Sr</b> |
| Rubidium   |           | Strontium |

|               |           |           |
|---------------|-----------|-----------|
| 55            | <b>Cs</b> | 56        |
| 2,8,18,18,8,1 |           | <b>Ba</b> |
| Cæsium        |           | Barium    |

|                  |           |           |
|------------------|-----------|-----------|
| 87               | <b>Fr</b> | 88        |
| 2,8,18,32,18,8,1 |           | <b>Ra</b> |
| 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                |
| <b>Sc</b>        | <b>Ti</b>         | <b>V</b>          | <b>Cr</b>         | <b>Mn</b>         | <b>Fe</b>         | <b>Co</b>         | <b>Ni</b>         | <b>Cu</b>         | <b>Zn</b>         |
| 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                |
| <b>Y</b>         | <b>Zr</b>         | <b>Nb</b>         | <b>Mo</b>         | <b>Tc</b>         | <b>Ru</b>         | <b>Rh</b>         | <b>Pd</b>         | <b>Ag</b>         | <b>Cd</b>         |
| 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                |
| <b>La</b>        | <b>Hf</b>         | <b>Ta</b>         | <b>W</b>          | <b>Re</b>         | <b>Os</b>         | <b>Ir</b>         | <b>Pt</b>         | <b>Au</b>         | <b>Hg</b>         |
| 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               |
| <b>Ac</b>        | <b>Rf</b>         | <b>Db</b>         | <b>Sg</b>         | <b>Bh</b>         | <b>Hs</b>         | <b>Mt</b>         | <b>Ds</b>         | <b>Rg</b>         | <b>Cn</b>         |
| 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>B</b>       | <b>C</b>       | <b>N</b>       | <b>O</b>       | <b>F</b>       | <b>Ne</b>      |
| 2,3            | 2,4            | 2,5            | 2,6            | 2,7            | 2,8            |
| Boron          | Carbon         | Nitrogen       | Oxygen         | Fluorine       | Neon           |
| 13             | 14             | 15             | 16             | 17             | 18             |
| <b>Al</b>      | <b>Si</b>      | <b>P</b>       | <b>S</b>       | <b>Cl</b>      | <b>Ar</b>      |
| 2,8,3          | 2,8,4          | 2,8,5          | 2,8,6          | 2,8,7          | 2,8,8          |
| Aluminium      | Silicon        | Phosphorus     | Sulfur         | Chlorine       | Argon          |
| 31             | 32             | 33             | 34             | 35             | 36             |
| <b>Ga</b>      | <b>Ge</b>      | <b>As</b>      | <b>Se</b>      | <b>Br</b>      | <b>Kr</b>      |
| 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             |
| <b>In</b>      | <b>Sn</b>      | <b>Sb</b>      | <b>Te</b>      | <b>I</b>       | <b>Xe</b>      |
| 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             |
| <b>Tl</b>      | <b>Pb</b>      | <b>Bi</b>      | <b>Po</b>      | <b>At</b>      | <b>Rn</b>      |
| 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      | <b>He</b> |  |
| 2      |           |  |
| Helium |           |  |

|          |          |          |          |          |           |
|----------|----------|----------|----------|----------|-----------|
| 5        | 6        | 7        | 8        | 9        | 10        |
| <b>B</b> | <b>C</b> | <b>N</b> | <b>O</b> | <b>F</b> | <b>Ne</b> |
| 2,3      | 2,4      | 2,5      | 2,6      | 2,7      | 2,8       |
| Boron    | Carbon   | Nitrogen | Oxygen   | Fluorine | Neon      |

|           |           |            |          |           |           |
|-----------|-----------|------------|----------|-----------|-----------|
| 13        | 14        | 15         | 16       | 17        | 18        |
| <b>Al</b> | <b>Si</b> | <b>P</b>   | <b>S</b> | <b>Cl</b> | <b>Ar</b> |
| 2,8,3     | 2,8,4     | 2,8,5      | 2,8,6    | 2,8,7     | 2,8,8     |
| Aluminium | Silicon   | Phosphorus | Sulfur   | Chlorine  | Argon     |

|           |           |           |           |           |           |
|-----------|-----------|-----------|-----------|-----------|-----------|
| 31        | 32        | 33        | 34        | 35        | 36        |
| <b>Ga</b> | <b>Ge</b> | <b>As</b> | <b>Se</b> | <b>Br</b> | <b>Kr</b> |
| 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          |
| <b>In</b>   | <b>Sn</b>   | <b>Sb</b>   | <b>Te</b>   | <b>I</b>    | <b>Xe</b>   |
| 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             |
| <b>Tl</b>      | <b>Pb</b>      | <b>Bi</b>      | <b>Po</b>      | <b>At</b>      | <b>Rn</b>      |
| 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            |
| <b>La</b>     | <b>Ce</b>     | <b>Pr</b>     | <b>Nd</b>     | <b>Pm</b>     | <b>Sm</b>     | <b>Eu</b>     | <b>Gd</b>     | <b>Tb</b>     | <b>Dy</b>     | <b>Ho</b>     | <b>Er</b>     | <b>Tm</b>     | <b>Yb</b>     | <b>Lu</b>     |
| 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              |
| <b>Ac</b>        | <b>Th</b>         | <b>Pa</b>        | <b>U</b>         | <b>Np</b>        | <b>Pu</b>        | <b>Am</b>        | <b>Cm</b>        | <b>Bk</b>        | <b>Cf</b>        | <b>Es</b>        | <b>Fm</b>        | <b>Md</b>        | <b>No</b>        | <b>Lr</b>        |
| 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       |

[BLANK PAGE]

DO NOT WRITE ON THIS PAGE

[BLANK PAGE]

DO NOT WRITE ON THIS PAGE