



National  
Qualifications  
2024

X857/77/11

**Physics  
Relationships sheet**

THURSDAY, 25 APRIL

9:00 AM – 12:00 NOON

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## Relationships required for Physics Advanced Higher

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

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

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

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

$$v = u + at$$

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

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

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

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

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

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

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

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

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

$$\omega = \omega_o + at$$

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

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

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

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

$$s = r\theta$$

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

$$a_t = r\alpha$$

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

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

$$E = hf$$

$$\omega = 2\pi f$$

$$mv r = \frac{nh}{2\pi}$$

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

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

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

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

$$I = \sum mr^2$$

$$\tau = Fr$$

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

$$\tau = I\alpha$$

$$F = qvB$$

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

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

$$L = I\omega$$

$$F = -ky$$

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

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

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

$$F = QE$$

$$V = Ed$$

$$W = QV$$

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

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

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

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

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

$$F = IlB \sin \theta$$

$$E = kA^2$$

$$F = qvB$$

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

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

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

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

$$opd = n \times gpd$$

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

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

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

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

$$n = \tan i_P$$

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

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

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

$$X_L = 2\pi f L$$

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

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

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

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

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

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

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

$d = \bar{v}t$	$W = QV$	$V_{peak} = \sqrt{2}V_{rms}$
$s = \bar{v}t$	$E = mc^2$	$I_{peak} = \sqrt{2}I_{rms}$
$v = u + at$	$E = hf$	$Q = It$
$s = ut + \frac{1}{2}at^2$	$E_K = hf - hf_0$	$V = IR$
$v^2 = u^2 + 2as$	$E_2 - E_1 = hf$	$P = IV = I^2R = \frac{V^2}{R}$
$s = \frac{1}{2}(u+v)t$	$T = \frac{1}{f}$	$R_T = R_1 + R_2 + \dots$
$W = mg$	$v = f\lambda$	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$
$F = ma$	$d \sin \theta = m\lambda$	$E = V + Ir$
$E_W = Fd$	$n = \frac{\sin \theta_1}{\sin \theta_2}$	$V_1 = \left( \frac{R_1}{R_1 + R_2} \right) V_S$
$E_P = mgh$	$\frac{\sin \theta_1}{\sin \theta_2} = \frac{\lambda_1}{\lambda_2} = \frac{v_1}{v_2}$	$\frac{V_1}{V_2} = \frac{R_1}{R_2}$
$E_K = \frac{1}{2}mv^2$	$\sin \theta_c = \frac{1}{n}$	$C = \frac{Q}{V}$
$P = \frac{E}{t}$	$I = \frac{k}{d^2}$	$E = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$
$p = mv$	$I = \frac{P}{A}$	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
<b>1</b> <b>H</b> 1 Hydrogen	<b>2</b> <b>(2)</b>	<b>3</b> <b>Li</b> 2,1	<b>4</b> <b>Be</b> 2,2	<b>5</b> <b>B</b> 2,3	<b>6</b> <b>C</b> 2,4	<b>7</b> <b>N</b> 2,5	<b>8</b> <b>O</b> 2,6
<b>Lithium</b>	<b>Beryllium</b>	<b>Boron</b>	<b>Nitrogen</b>	<b>Oxygen</b>	<b>Fluorine</b>	<b>Neon</b>	<b>He</b> 2 Helium
<b>11</b> <b>Na</b> 2,8,1	<b>12</b> <b>Mg</b> 2,8,2	<b>13</b> <b>Al</b> 2,8,3	<b>14</b> <b>Si</b> 2,8,4	<b>15</b> <b>P</b> 2,8,5	<b>16</b> <b>S</b> 2,8,6	<b>17</b> <b>Cl</b> 2,8,7	<b>18</b> <b>Ar</b> 2,8,8
<b>Sodium</b>	<b>Magnesium</b>	<b>Aluminium</b>	<b>Silicon</b>	<b>Phosphorus</b>	<b>Sulfur</b>	<b>Chlorine</b>	<b>Argon</b>
<b>19</b> <b>K</b> 2,8,8,1	<b>20</b> <b>Ca</b> 2,8,8,2	<b>21</b> <b>Sc</b> 2,8,9,2	<b>22</b> <b>Ti</b> 2,8,10,2	<b>23</b> <b>V</b> 2,8,11,2	<b>24</b> <b>Cr</b> 2,8,13,1	<b>25</b> <b>Mn</b> 2,8,13,2	<b>26</b> <b>Fe</b> 2,8,14,2
<b>Potassium</b>	<b>Calcium</b>	<b>Scandium</b>	<b>Titanium</b>	<b>Vanadium</b>	<b>Chromium</b>	<b>Manganese</b>	<b>Iron</b>
<b>37</b> <b>Rb</b> 2,8,18,8,1	<b>38</b> <b>Sr</b> 2,8,18,8,2	<b>39</b> <b>Y</b> 2,8,18,9,2	<b>40</b> <b>Zr</b> 2,8,18,10,2	<b>41</b> <b>Nb</b> 2,8,18,12,1	<b>42</b> <b>Mo</b> 2,8,18,13,1	<b>43</b> <b>Tc</b> 2,8,18,13,2	<b>44</b> <b>Ru</b> 2,8,18,15,1
<b>Rubidium</b>	<b>Strontrium</b>	<b>Yttrium</b>	<b>Zirconium</b>	<b>Niobium</b>	<b>Molybdenum</b>	<b>Technetium</b>	<b>Ruthenium</b>
<b>55</b> <b>Cs</b> 2,8,18,18,8,1	<b>56</b> <b>Ba</b> 2,8,18,18,8,2	<b>57</b> <b>La</b> 2,8,18,18,9,2	<b>72</b> <b>Hf</b> 2,8,18,32,10,2	<b>73</b> <b>Ta</b> 2,8,18,32,32,11,2	<b>74</b> <b>W</b> 2,8,18,32,12,2	<b>75</b> <b>Re</b> 2,8,18,32,13,2	<b>76</b> <b>Os</b> 2,8,18,32,14,2
<b>Cæsium</b>	<b>Barium</b>	<b>Lanthanum</b>	<b>Hafnium</b>	<b>Tantalum</b>	<b>Rhenium</b>	<b>Iridium</b>	<b>Palladium</b>
<b>87</b> <b>Fr</b> 2,8,18,32,18,8,1	<b>88</b> <b>Ra</b> 2,8,18,32,18,8,2	<b>89</b> <b>Ac</b> 2,8,18,32,18,9,2	<b>104</b> <b>Rf</b> 2,8,18,32,32,10,2	<b>105</b> <b>Db</b> 2,8,18,32,32,11,2	<b>106</b> <b>Sg</b> 2,8,18,32,32,12,2	<b>107</b> <b>Bh</b> 2,8,18,32,32,13,2	<b>108</b> <b>Hs</b> 2,8,18,32,32,14,2
<b>Francium</b>	<b>Radium</b>	<b>Actinium</b>	<b>Rutherfordium</b>	<b>Dubnium</b>	<b>Seaborgium</b>	<b>Bohrium</b>	<b>Hassium</b>
<b>Lanthanides</b>	<b>57</b> <b>La</b> 2,8,18,18,9,2	<b>58</b> <b>Ce</b> 2,8,18,20,8,2	<b>59</b> <b>Pr</b> 2,8,18,21,8,2	<b>60</b> <b>Nd</b> 2,8,18,22,8,2	<b>61</b> <b>Pm</b> 2,8,18,23,8,2	<b>62</b> <b>Sm</b> 2,8,18,24,8,2	<b>63</b> <b>Eu</b> 2,8,18,25,8,2
	<b>Lanthanum</b>	<b>Cerium</b>	<b>Praseodymium</b>	<b>Neodymium</b>	<b>Promethium</b>	<b>Samarium</b>	<b>Europtium</b>
<b>Actinides</b>	<b>89</b> <b>Ac</b> 2,8,18,32,18,9,2	<b>90</b> <b>Th</b> 2,8,18,32,18,10,2	<b>91</b> <b>Pa</b> 2,8,18,32,20,9,2	<b>92</b> <b>U</b> 2,8,19,9,2	<b>93</b> <b>Np</b> 2,8,18,32,22,9,2	<b>94</b> <b>Pu</b> 2,8,18,32,24,8,2	<b>95</b> <b>Am</b> 2,8,18,32,25,8,2
	<b>Thorium</b>	<b>Protactinium</b>	<b>Uranium</b>	<b>Neptunium</b>	<b>Plutonium</b>	<b>Americium</b>	<b>Curium</b>
	<b>Berkelium</b>	<b>Californium</b>	<b>Einsteinium</b>	<b>Fermium</b>	<b>Mendelevium</b>	<b>Noberium</b>	<b>Lawrencium</b>

**Key**

<b>Atomic number</b>
<b>Symbol</b>
<b>Electron arrangement</b>

### Transition elements

<b>13</b> <b>Al</b> 2,8,3	<b>14</b> <b>Si</b> 2,8,4	<b>15</b> <b>P</b> 2,8,5	<b>16</b> <b>S</b> 2,8,6	<b>17</b> <b>Cl</b> 2,8,7	<b>18</b> <b>Ar</b> 2,8,8	<b>19</b> <b>Kr</b> 2,8,18,8	<b>20</b> <b>Xe</b> 2,8,18,8, Xenon
<b>Aluminium</b>	<b>Silicon</b>	<b>Phosphorus</b>	<b>Sulfur</b>	<b>Chlorine</b>	<b>Argon</b>	<b>Krypton</b>	<b>Xenon</b>
<b>31</b> <b>Ga</b> 2,8,18,3	<b>32</b> <b>Ge</b> 2,8,18,4	<b>33</b> <b>As</b> 2,8,18,5	<b>34</b> <b>Se</b> 2,8,18,6	<b>35</b> <b>Br</b> 2,8,18,7	<b>36</b> <b>I</b> 2,8,18,8	<b>37</b> <b>Xe</b> 2,8,18,8, Krypton	<b>38</b> <b>Kr</b> 2,8,18,8, Xenon
<b>Gallium</b>	<b>Germanium</b>	<b>Arsenic</b>	<b>Selenium</b>	<b>Bromine</b>	<b>Iodine</b>	<b>Thallium</b>	<b>Radon</b>
<b>49</b> <b>In</b> 2,8,18,3	<b>50</b> <b>Sn</b> 2,8,18,4	<b>51</b> <b>SB</b> 2,8,18,5	<b>52</b> <b>Te</b> 2,8,18,6	<b>53</b> <b>I</b> 2,8,18,7	<b>54</b> <b>Xe</b> 2,8,18,8, Xenon	<b>55</b> <b>At</b> 2,8,18,7, Astatine	<b>56</b> <b>Rn</b> 2,8,18,8, Radon
<b>Inium</b>	<b>Tin</b>	<b>Antimony</b>	<b>Tellurium</b>	<b>Iodine</b>	<b>Bismuth</b>	<b>Polonium</b>	<b>Mendelevium</b>
<b>81</b> <b>Tl</b> 2,8,18,3	<b>82</b> <b>Pb</b> 2,8,18,4	<b>83</b> <b>Bi</b> 2,8,18,5	<b>84</b> <b>Po</b> 2,8,18,6	<b>85</b> <b>At</b> 2,8,18,7	<b>86</b> <b>Rn</b> 2,8,18,8, Radon	<b>87</b> <b>Rn</b> 2,8,18,8, Radon	<b>88</b> <b>Rn</b> 2,8,18,8, Radon
<b>Thallium</b>	<b>Lead</b>	<b>Bismuth</b>	<b>Polonium</b>	<b>Astatine</b>	<b>Radon</b>	<b>Radon</b>	<b>Radon</b>

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