



National  
Qualifications  
2021 ASSESSMENT RESOURCE

X857/77/11

**Physics**  
**Relationships sheet**

Duration — 3 hours

---



\* X 8 5 7 7 7 1 1 \*

## Relationships required for Physics Advanced Higher

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

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

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

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

$$v = u + at$$

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

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

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

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

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

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

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

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

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

$$\omega = \omega_o + at$$

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

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

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

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

$$s = r\theta$$

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

$$a_t = r\alpha$$

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

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

$$E = hf$$

$$\omega = 2\pi f$$

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

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

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

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

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

$$I = \sum mr^2$$

$$\tau = Fr$$

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

$$\tau = I\alpha$$

$$F = qvB$$

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

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

$$L = I\omega$$

$$F = -ky$$

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

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

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

$$F = QE$$

$$V = Ed$$

$$W = QV$$

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

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

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

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

$$F = IlB \sin \theta$$

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

$$F = qvB$$

$$E = kA^2$$

$$\tau = RC$$

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

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

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

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

$$opd = n \times gpd$$

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

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

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

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

$$n = \tan i_P$$

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

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

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

$$X_L = 2\pi f L$$

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

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

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

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

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

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

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

$d = \bar{v}t$	$W = QV$	$V_{peak} = \sqrt{2}V_{rms}$
$s = \bar{v}t$	$E = mc^2$	$I_{peak} = \sqrt{2}I_{rms}$
$v = u + at$	$E = hf$	$Q = It$
$s = ut + \frac{1}{2}at^2$	$E_K = hf - hf_0$	$V = IR$
$v^2 = u^2 + 2as$	$E_2 - E_1 = hf$	$P = IV = I^2R = \frac{V^2}{R}$
$s = \frac{1}{2}(u+v)t$	$T = \frac{1}{f}$	$R_T = R_1 + R_2 + \dots$
$W = mg$	$v = f\lambda$	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$
$F = ma$	$d \sin \theta = m\lambda$	$E = V + Ir$
$E_W = Fd$	$n = \frac{\sin \theta_1}{\sin \theta_2}$	$V_1 = \left( \frac{R_1}{R_1 + R_2} \right) V_S$
$E_P = mgh$	$\frac{\sin \theta_1}{\sin \theta_2} = \frac{\lambda_1}{\lambda_2} = \frac{v_1}{v_2}$	$\frac{V_1}{V_2} = \frac{R_1}{R_2}$
$E_K = \frac{1}{2}mv^2$	$\sin \theta_c = \frac{1}{n}$	$C = \frac{Q}{V}$
$P = \frac{E}{t}$	$I = \frac{k}{d^2}$	$E = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$
$p = mv$	$I = \frac{P}{A}$	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															
(1)		(2)															
<b>1</b>	<b>H</b>	<b>3</b>	<b>B</b>	<b>5</b>	<b>B</b>	<b>6</b>	<b>N</b>	<b>7</b>	<b>O</b>	<b>8</b>	<b>F</b>	<b>9</b>	<b>He</b>	<b>10</b>	<b>Ne</b>	<b>12</b>	<b>He</b>
Hydrogen		Li	Be			2,1	2,2	Lithium	Beryllium			2,7		2,8	Neon		(18)
<b>11</b>	<b>Na</b>	<b>12</b>	<b>Mg</b>	<b>13</b>	<b>Al</b>	<b>14</b>	<b>Si</b>	<b>15</b>	<b>P</b>	<b>16</b>	<b>S</b>	<b>17</b>	<b>Cl</b>	<b>18</b>	<b>Ar</b>	<b>19</b>	<b>H</b>
Lithium	Beryllium	Magnesium		Aluminium	Silicon	Phosphorus	Sulfur	Chlorine		Oxygen	Fluorine		Argon		Hydrogen		
<b>19</b>	<b>K</b>	<b>20</b>	<b>Ca</b>	<b>21</b>	<b>Ti</b>	<b>22</b>	<b>V</b>	<b>23</b>	<b>Cr</b>	<b>24</b>	<b>Mn</b>	<b>25</b>	<b>Fe</b>	<b>26</b>	<b>Co</b>	<b>27</b>	<b>Ni</b>
Potassium	Calcium	Scandium	Titanium	Vanadium	Chromium	Manganese	Iron	Cobalt	Nickel	Copper	Zinc						
<b>37</b>	<b>Rb</b>	<b>38</b>	<b>Sr</b>	<b>39</b>	<b>Zr</b>	<b>40</b>	<b>Nb</b>	<b>41</b>	<b>Mo</b>	<b>42</b>	<b>Tc</b>	<b>43</b>	<b>Ru</b>	<b>44</b>	<b>Rh</b>	<b>45</b>	<b>Pd</b>
Rubidium	Strontium	Yttrium	Zirconium	Niobium	Molybdenum	Tantalum	Rhenium	Ruthenium	Rhodium	Palladium							
<b>55</b>	<b>Cs</b>	<b>56</b>	<b>Ba</b>	<b>57</b>	<b>La</b>	<b>58</b>	<b>Hf</b>	<b>59</b>	<b>Ta</b>	<b>60</b>	<b>W</b>	<b>61</b>	<b>Re</b>	<b>62</b>	<b>Os</b>	<b>63</b>	<b>Hg</b>
Caesium	Barium	Lanthanum	Hafnium	Tantalum	Tungsten	Rhenium	Rhenium	Rhenium	Rhenium	Rhenium							
<b>87</b>	<b>Fr</b>	<b>88</b>	<b>Ra</b>	<b>89</b>	<b>Ac</b>	<b>90</b>	<b>Rf</b>	<b>91</b>	<b>Db</b>	<b>92</b>	<b>Sg</b>	<b>93</b>	<b>Bh</b>	<b>94</b>	<b>Hs</b>	<b>95</b>	<b>Mt</b>
Francium	Radium	Actinium	Rutherfordium	Dubnium	Seaborgium	Berthium	Hassium	Metasternium	Darmstadtium	Roentgenium	Copernicium						
<b>Transition elements</b>																	
<b>57</b>	<b>La</b>	<b>58</b>	<b>Ce</b>	<b>59</b>	<b>Pr</b>	<b>60</b>	<b>Nd</b>	<b>61</b>	<b>Pm</b>	<b>62</b>	<b>Sm</b>	<b>63</b>	<b>Eu</b>	<b>64</b>	<b>Gd</b>	<b>65</b>	<b>Tb</b>
Lanthanum	Cerium	Praseodymium	Neodymium	Promethium	Samarium	Europium	Gadolinium	Terbium	Dysprosium	Holmium	Erbium						
<b>89</b>	<b>Ac</b>	<b>90</b>	<b>Th</b>	<b>91</b>	<b>Pa</b>	<b>92</b>	<b>U</b>	<b>93</b>	<b>Np</b>	<b>94</b>	<b>Pu</b>	<b>95</b>	<b>Am</b>	<b>96</b>	<b>Cm</b>	<b>97</b>	<b>Bk</b>
Actinium	Thorium	Protactinium	Uranium	Neptunium	Plutonium	Americium	Curium	Berkelium	Californium	Einsteinium	Fermium						
<b>Lanthanides</b>																	
<b>13</b>	<b>Al</b>	<b>14</b>	<b>Si</b>	<b>15</b>	<b>P</b>	<b>16</b>	<b>S</b>	<b>17</b>	<b>Cl</b>	<b>18</b>	<b>Ar</b>	<b>19</b>	<b>Ne</b>	<b>20</b>	<b>Ca</b>	<b>21</b>	<b>H</b>
Boron		Carbon	Nitrogen	Oxygen													
<b>31</b>	<b>Ga</b>	<b>32</b>	<b>Ge</b>	<b>33</b>	<b>As</b>	<b>34</b>	<b>Se</b>	<b>35</b>	<b>Br</b>	<b>36</b>	<b>Kr</b>	<b>37</b>	<b>Xe</b>	<b>38</b>	<b>Rn</b>	<b>39</b>	<b>Lu</b>
Aluminium		Silicon	Phosphorus	Sulfur													
<b>49</b>	<b>In</b>	<b>50</b>	<b>Sn</b>	<b>51</b>	<b>Sb</b>	<b>52</b>	<b>Te</b>	<b>53</b>	<b>I</b>	<b>54</b>	<b>Xe</b>	<b>55</b>	<b>At</b>	<b>56</b>	<b>Rn</b>	<b>57</b>	<b>Lu</b>
Gallium		Germanium	Arsenic	Selenium													
<b>49</b>	<b>In</b>	<b>50</b>	<b>Sn</b>	<b>51</b>	<b>Sb</b>	<b>52</b>	<b>Te</b>	<b>53</b>	<b>I</b>	<b>54</b>	<b>Xe</b>	<b>55</b>	<b>At</b>	<b>56</b>	<b>Rn</b>	<b>57</b>	<b>Lu</b>
<b>81</b>	<b>Tl</b>	<b>82</b>	<b>Pb</b>	<b>83</b>	<b>Bi</b>	<b>84</b>	<b>Po</b>	<b>85</b>	<b>At</b>	<b>86</b>	<b>Rn</b>	<b>87</b>	<b>At</b>	<b>88</b>	<b>Rn</b>	<b>89</b>	<b>Lu</b>
<b>81</b>	<b>Tl</b>	<b>82</b>	<b>Pb</b>	<b>83</b>	<b>Bi</b>	<b>84</b>	<b>Po</b>	<b>85</b>	<b>At</b>	<b>86</b>	<b>Rn</b>	<b>87</b>	<b>At</b>	<b>88</b>	<b>Rn</b>	<b>89</b>	<b>Lu</b>
<b>81</b>	<b>Tl</b>	<b>82</b>	<b>Pb</b>	<b>83</b>	<b>Bi</b>	<b>84</b>	<b>Po</b>	<b>85</b>	<b>At</b>	<b>86</b>	<b>Rn</b>	<b>87</b>	<b>At</b>	<b>88</b>	<b>Rn</b>	<b>89</b>	<b>Lu</b>
<b>81</b>	<b>Tl</b>	<b>82</b>	<b>Pb</b>	<b>83</b>	<b>Bi</b>	<b>84</b>	<b>Po</b>	<b>85</b>	<b>At</b>	<b>86</b>	<b>Rn</b>	<b>87</b>	<b>At</b>	<b>88</b>	<b>Rn</b>	<b>89</b>	<b>Lu</b>
<b>81</b>	<b>Tl</b>	<b>82</b>	<b>Pb</b>	<b>83</b>	<b>Bi</b>	<b>84</b>	<b>Po</b>	<b>85</b>	<b>At</b>	<b>86</b>	<b>Rn</b>	<b>87</b>	<b>At</b>	<b>88</b>	<b>Rn</b>	<b>89</b>	<b>Lu</b>
<b>81</b>	<b>Tl</b>	<b>82</b>	<b>Pb</b>	<b>83</b>	<b>Bi</b>	<b>84</b>	<b>Po</b>	<b>85</b>	<b>At</b>	<b>86</b>	<b>Rn</b>	<b>87</b>	<b>At</b>	<b>88</b>	<b>Rn</b>	<b>89</b>	<b>Lu</b>
<b>81</b>	<b>Tl</b>	<b>82</b>	<b>Pb</b>	<b>83</b>	<b>Bi</b>	<b>84</b>	<b>Po</b>	<b>85</b>	<b>At</b>	<b>86</b>	<b>Rn</b>	<b>87</b>	<b>At</b>	<b>88</b>	<b>Rn</b>	<b>89</b>	<b>Lu</b>
<b>81</b>	<b>Tl</b>	<b>82</b>	<b>Pb</b>	<b>83</b>	<b>Bi</b>	<b>84</b>	<b>Po</b>	<b>85</b>	<b>At</b>	<b>86</b>	<b>Rn</b>	<b>87</b>	<b>At</b>	<b>88</b>	<b>Rn</b>	<b>89</b>	<b>Lu</b>
<b>81</b>	<b>Tl</b>	<b>82</b>	<b>Pb</b>	<b>83</b>	<b>Bi</b>	<b>84</b>	<b>Po</b>	<b>85</b>	<b>At</b>	<b>86</b>	<b>Rn</b>	<b>87</b>	<b>At</b>	<b>88</b>	<b>Rn</b>	<b>89</b>	<b>Lu</b>
<b>81</b>	<b>Tl</b>	<b>82</b>	<b>Pb</b>	<b>83</b>	<b>Bi</b>	<b>84</b>	<b>Po</b>	<b>85</b>	<b>At</b>	<b>86</b>	<b>Rn</b>	<b>87</b>	<b>At</b>	<b>88</b>	<b>Rn</b>	<b>89</b>	<b>Lu</b>
<b>81</b>	<b>Tl</b>	<b>82</b>	<b>Pb</b>	<b>83</b>	<b>Bi</b>	<b>84</b>	<b>Po</b>	<b>85</b>	<b>At</b>	<b>86</b>	<b>Rn</b>	<b>87</b>	<b>At</b>	<b>88</b>	<b>Rn</b>	<b>89</b>	<b>Lu</b>
<b>81</b>	<b>Tl</b>	<b>82</b>	<b>Pb</b>	<b>83</b>	<b>Bi</b>	<b>84</b>	<b>Po</b>	<b>85</b>	<b>At</b>	<b>86</b>	<b>Rn</b>	<b>87</b>	<b>At</b>	<b>88</b>	<b>Rn</b>	<b>89</b>	<b>Lu</b>
<b>81</b>	<b>Tl</b>	<b>82</b>	<b>Pb</b>	<b>83</b>	<b>Bi</b>	<b>84</b>	<b>Po</b>	<b>85</b>	<b>At</b>	<b>86</b>	<b>Rn</b>	<b>87</b>	<b>At</b>	<b>88</b>	<b>Rn</b>	<b>89</b>	<b>Lu</b>
<b>81</b>	<b>Tl</b>	<b>82</b>	<b>Pb</b>	<b>83</b>	<b>Bi</b>	<b>84</b>	<b>Po</b>	<b>85</b>	<b>At</b>	<b>86</b>	<b>Rn</b>	<b>87</b>	<b>At</b>	<b>88</b>	<b>Rn</b>	<b>89</b>	<b>Lu</b>
<b>81</b>	<b>Tl</b>	<b>82</b>	<b>Pb</b>	<b>83</b>	<b>Bi</b>	<b>84</b>	<b>Po</b>	<b>85</b>	<b>At</b>	<b>86</b>	<b>Rn</b>	<b>87</b>	<b>At</b>	<b>88</b>	<b>Rn</b>	<b>89</b>	<b>Lu</b>
<b>81</b>	<b>Tl</b>	<b>82</b>	<b>Pb</b>	<b>83</b>	<b>Bi</b>	<b>84</b>	<b>Po</b>	<b>85</b>	<b>At</b>	<b>86</b>	<b>Rn</b>	<b>87</b>	<b>At</b>	<b>88</b>	<b>Rn</b>	<b>89</b>	<b>Lu</b>
<b>81</b>	<b>Tl</b>	<b>82</b>	<b>Pb</b>	<b>83</b>	<b>Bi</b>	<b>84</b>	<b>Po</b>	<b>85</b>	<b>At</b>	<b>86</b>	<b>Rn</b>	<b>87</b>	<b>At</b>	<b>88</b>	<b>Rn</b>	<b>89</b>	<b>Lu</b>
<b>81</b>	<b>Tl</b>	<b>82</b>	<b>Pb</b>	<b>83</b>	<b>Bi</b>	<b>84</b>	<b>Po</b>	<b>85</b>	<b>At</b>	<b>86</b>	<b>Rn</b>	<b>87</b>	<b>At</b>	<b>88</b>	<b>Rn</b>	<b>89</b>	<b>Lu</b>
<b>81</b>	<b>Tl</b>	<b>82</b>	<b>Pb</b>	<b>83</b>	<b>Bi</b>	<b>84</b>	<b>Po</b>	<b>85</b>	<b>At</b>	<b>86</b>	<b>Rn</b>	<b>87</b>	<b>At</b>	<b>88</b>	<b>Rn</b>	<b>89</b>	<b>Lu</b>
<b>81</b>	<b>Tl</b>	<b>82</b>	<b>Pb</b>	<b>83</b>	<b>Bi</b>	<b>84</b>	<b>Po</b>	<b>85</b>	<b>At</b>	<b>86</b>	<b>Rn</b>	<b>87</b>	<b>At</b>	<b>88</b>	<b>Rn</b>	<b>89</b>	<b>Lu</b>
<b>81</b>	<b>Tl</b>	<b>82</b>	<b>Pb</b>	<b>83</b>	<b>Bi</b>	<b>84</b>	<b>Po</b>	<b>85</b>	<b>At</b>	<b>86</b>	<b>Rn</b>	<b>87</b>	<b>At</b>	<b>88</b>	<b>Rn</b>	<b>89</b>	<b>Lu</b>
<b>81</b>	<b>Tl</b>	<b>82</b>	<b>Pb</b>	<b>83</b>	<b>Bi</b>	<b>84</b>	<b>Po</b>	<b>85</b>	<b>At</b>	<b>86</b>	<b>Rn</b>	<b>87</b>	<b>At</b>	<b>88</b>	<b>Rn</b>	<b>89</b>	<b>Lu</b>
<b>81</b>	<b>Tl</b>	<b>82</b>	<b>Pb</b>	<b>83</b>	<b>Bi</b>	<b>84</b>	<b>Po</b>	<b>85</b>	<b>At</b>	<b>86</b>	<b>Rn</b>	<b>87</b>	<b>At</b>	<b>88</b>	<b>Rn</b>	<b>89</b>	<b>Lu</b>
<b>81</b>	<b>Tl</b>	<b>82</b>	<b>Pb</b>	<b>83</b>	<b>Bi</b> </												

**[BLANK PAGE]**

**DO NOT WRITE ON THIS PAGE**

[BLANK PAGE]

**DO NOT WRITE ON THIS PAGE**