



# Level 3 Technical Level

## DESIGN ENGINEERING

## MECHATRONIC ENGINEERING

### Unit 1 Materials Technology and Science

#### Formula sheet

|                                                                                                  |                                                                                                                                                                         |
|--------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Area of a circle<br>$A = \pi r^2$ or $A = \frac{\pi D^2}{4}$                                     | Density<br>$\rho = \frac{m}{V}$                                                                                                                                         |
| Stress<br>$\sigma = \frac{F}{A}$                                                                 | Strain<br>$\varepsilon = \frac{\delta L}{L}$                                                                                                                            |
| Angular measure<br>$360^\circ \equiv 2\pi$ radians                                               | Newton's second law<br>$F = ma$                                                                                                                                         |
| Trigonometry<br>$\sin = \frac{opp}{hyp}$ , $\cos = \frac{adj}{hyp}$ and $\tan = \frac{opp}{adj}$ | Young's Modulus<br>$E = \frac{\sigma}{\varepsilon}$                                                                                                                     |
| Ohm's Law<br>$V = IR$                                                                            | Electrical power<br>$P = VI$ , $P = I^2 R$ and $P = \frac{V^2}{R}$                                                                                                      |
| Resistance in series<br>$R_{total} = R_1 + R_2 + R_3 \dots$                                      | Resistance in parallel<br>$R_{total} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \dots$<br><br>Two resistors in parallel<br>$R_{total} = \frac{R_1 R_2}{R_1 + R_2}$ |
| Straight line graph<br>$y = mx + c$                                                              | Energy<br>$PE = mgh$ and $KE = \frac{mv^2}{2}$                                                                                                                          |
| Frequency<br>$f = \frac{1}{T}$ and $f = \frac{\omega}{2\pi}$                                     | Boyle's law<br>$P_1 V_1 = P_2 V_2$                                                                                                                                      |

|                                                                               |                                                                                                                                      |
|-------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|
| <p>Charles' law</p> $\frac{V_1}{T_1} = \frac{V_2}{T_2}$                       | <p>The combined gas laws</p> $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$                                                             |
| <p>The equation of state</p> $\frac{PV}{T} = nR$                              | <p>The pressure law</p> $\frac{P_1}{T_1} = \frac{P_2}{T_2}$                                                                          |
| <p>Torque</p> $T = Fr$                                                        | <p>Gear ratio (2 gears)</p> $R = \frac{\omega_{in}}{\omega_{out}} = \frac{N_{out}}{N_{in}}$                                          |
| <p>Friction</p> $F = \mu N$                                                   | <p>Efficiency</p> $\eta = \frac{\text{Output}}{\text{Input}} \text{ and } \eta_{\%} = \frac{\text{Output}}{\text{Input}} \times 100$ |
| <p>Conversion from bar to Pascals</p> $1 \text{ bar} = 10^5 \text{ N m}^{-2}$ | <p>The gravitation constant</p> $g = 9.81 \text{ m s}^{-2}$                                                                          |