BTEC

Pearson BTEC Level 3 Nationals

Engineering

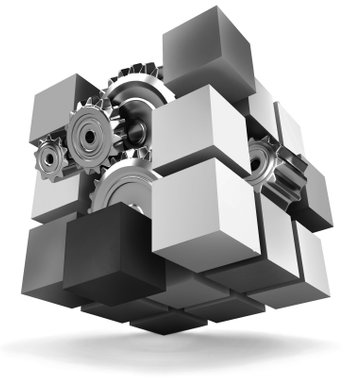
Information Booklet of Formulae and Constants
Unit 1: Engineering Principles

Extended Certificate, Foundation Diploma, Diploma, Extended Diploma in Engineering and all titles – Manufacturing/Aeronautical/ Computer/Electrical and Electronic/Mechanical Engineering.

Sample assessment material for first teaching September 2016

Instructions

- You will need the information in this booklet to answer most questions.
- Read the information carefully.
- You must **not** write your answers in this booklet.
- Only your answers given in the question paper will be marked.



Paper reference
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Turn over

Formulae and Constant

Static and Direct Current electricity theory

Current	$I = \frac{q}{t}$
Coulomb's law	$F = \frac{q_1 q_2}{4\pi\varepsilon_0 r^2}$
Resistance	$R = \frac{\rho l}{A}$
Resistance: temperature coefficient	$\frac{\Delta R}{R_0} = \alpha\Delta T$
Ohm's law	$I = \frac{V}{R}$
Total for resistors in series	$R_T = R_1 + R_2 + R_3$
Total for resistors in parallel	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \ldots$
Power	$P = IV,\ P = I^2R,\ P = \frac{V^2}{R}$
Efficiency	$E = \frac{P_{out}}{P_{in}}$
Kirchhoff's current law	$I = I_1 + I_2 + I_3$
Kirchhoff's voltage law	$V = V_1 + V_2 + V_3$ or $\sum PD = \sum IR$

Capacitance

Electric field strength	$E = \frac{F}{q}$
Electric field strength: uniform electric fields	$E = \frac{V}{d}$
Capacitance	$C = \frac{\varepsilon A}{d}$
Time constant	$\tau = RC$
Charged stored	$Q = CV$
Energy stored in a capacitor	$W = \frac{1}{2}CV^2$
Capacitors in series	$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \ldots.$
Capacitors in parallel	$C_T = C_1 + C_2 + C_3$
Voltage decay on capacitor discharge	$v_c = Ve^{(-t/\tau)}$

Magnetism and electromagnetism

Magnetic flux density	$B = \frac{\phi}{A}$
Magneto motive force	$F_m = NI$
Magnetic field strength or magnetising force	$H = \frac{NI}{l}$

Permeability	$\frac{B}{H} = \mu_0\mu_r$
Reluctance	$S = \frac{F_m}{\phi}$
Induced EMF	$E = BLv,\ E = -N\frac{d\phi}{dt} = -L\frac{dI}{dt}$
Energy stored in an inductor	$W = \frac{1}{2}LI^2$
Inductance of a coil	$L = \frac{N\phi}{I}$
Transformer equation	$\frac{\boldsymbol{V_1}}{\boldsymbol{V_2}} = \frac{\boldsymbol{N_1}}{\boldsymbol{N_2}}$

Single phase Alternating Current theory

Time period	$T = \frac{1}{f}$
Capacitive reactance	$X_C = \frac{1}{2\pi fC}$
Inductive reactance	$X_L = 2\pi fL$
Root mean square voltage	$RMS\ voltage = \frac{peak\ voltage}{\sqrt{2}}$
Total impedance of an inductor in series with a resistance	$Z = \sqrt{{X_L}^2 + R^2}$
Total impedance of a capacitor in series with a resistance	$Z = \sqrt{{X_C}^2 + R^2}$
Average waveform value average value	$Average\ value = \frac{2}{\pi} \times maximum\ value$
Form factor of a waveform	$Form\ factor = \frac{RMS\ value}{average\ value}$

Laws of Mathematics

Rules of indices

$a^m \times a^n = a^{(m+n)}$

$a^m \div a^n = a^{(m-n)}$

$(a^m)^n = a^{mn}$

Rules of logarithms

$log\ AB = log\ A + logB$

$log\frac{A}{B} = logA - logB$

$logA^x = xlogA$

Trigonometric rules

Sine rule

$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$ or $\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$

Cosine rule

$a^2 = b^2 + c^2 - 2bc\cos A$

Volume and area of regular shapes

length of an arc of a circle	$s = r\theta$
area of a sector of a circle	$A = \frac{1}{2}r^2\theta$
volume of a cylinder	$V = \pi r^2 h$
total surface area of a cylinder	$TSA = 2\pi rh + 2\pi r^2$
volume of sphere	$V = \frac{4}{3}\pi r^3$
surface area of a sphere	$SA = 4\pi r^2$
volume of a cone	$V = \frac{1}{3}\pi r^2 h$
curved surface area of cone	$CSA = \pi rl$

Quadratic formula

To solve $ax^2 + bx + c = 0$, $a \neq 0$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Equations of linear motion with uniform acceleration

$v = u + at$

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

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

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

Stress and strain

Direct stress	$\sigma = \frac{F}{A}$
Direct strain	$\varepsilon = \frac{\Delta L}{L}$
Shear stress	$\tau = \frac{F}{A}$
Shear strain	$\gamma = \frac{a}{b}$
Modulus of elasticity	$E = \frac{\sigma}{\varepsilon}$
Modulus of rigidity	$G = \frac{\tau}{\gamma}$

Work, power, energy and forces

Force	$F = ma$
Resultant force	$F_x = F\cos\theta$, $F_y = F\sin\theta$ (where θ is measured from the horizontal)
Mechanical work	$W = Fs$
Force to overcome limiting friction	$F = \mu N$
Gravitational potential energy	$PE = mgh$
Kinetic energy	$\text{KE} = \frac{1}{2}mv^2$

Gas laws

Boyle's law	pV = constant
Charles's law	$\frac{V}{T}$ = constant
General gas equation	$\frac{pV}{T}$ = constant

Angular parameters

Centripetal acceleration	$a = \omega^2 r = \frac{v^2}{r}$

Power	$P = T\omega$
Rotational Kinetic energy	$KE = \frac{1}{2} I\omega^2$
Angular frequency	$\omega = 2\pi f$
Frequency	$\mathrm{f} = \frac{1}{\text{time period}}$

2π radians $= 360°$

Physical constants

Acceleration due to gravity	$g = 9.81\text{m/s}^2$
Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\text{F/m}$
Permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\text{H/m}$

Thermodynamic principles

Sensible heat	$Q = mc\Delta T$
Latent heat	$Q = ml$
Entropy and enthalpy	$H = U + pV$
Linear expansivity	$\Delta L = \alpha L \Delta T$

Fluid principles

Continuity of volumetric flow	$A_1 v_1 = A_2 v_2$
Continuity of mass flow	$\rho A_1 v_1 = \rho A_2 v_2$
Hydrostatic thrust on an immersed plane surface	$F = \rho g A x$