203-9P1-DW – Formulas and Constants

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EQUILIBRIUM:

Vectors:

$F_x = F\cos\theta$ $\quad F = \sqrt{F_x^2 + F_y^2}$

$F_y = F\sin\theta$ $\quad \theta = \tan^{-1}(F_y/F_x)$

Torque: $\tau_z = \pm F\,d$
Moment arm: $d = r\sin\theta$
Torque:

$$\tau_z = F\,r\sin\theta$$

Equilibrium:

$\sum F_x = 0\,\mathrm{N}$ $\quad \sum F_y = 0\,\mathrm{N}$ $\quad \sum \tau_z = 0\,\mathrm{N\cdot m}$

MATERIALS:

Stress: $\sigma = F/A$
Strain: $\epsilon = \Delta L/L_\mathrm{i}$
Elastic modulus: $\mathscr{Y} = \Delta\sigma/\Delta\epsilon$
Hooke's Law: $F = kx$, where $k = \mathscr{Y}A/L$

ENERGY, WORK & POWER:

Thermal energy: $\Delta E_\mathrm{Th} = m\mathscr{C}\,\Delta T$
Mixing: $T_\mathrm{final} = \frac{m_\mathrm{A}\mathscr{C}_\mathrm{A}T_\mathrm{A,i} + m_\mathrm{B}\mathscr{C}_\mathrm{B}T_\mathrm{B,i}}{m_\mathrm{A}\mathscr{C}_\mathrm{A} + m_\mathrm{B}\mathscr{C}_\mathrm{B}}$
Conduction: $P_\mathrm{Th} = (\mathscr{K}A/L)\left(T_\mathrm{env} - T_\mathrm{sys}\right)$

Speed: $v = \Delta x/\Delta t$ $\quad \omega = \Delta\theta/\Delta t$
Kinetic energy: $K = \frac{1}{2}m\,v^2$ $\quad K = \frac{1}{2}\mathscr{I}\omega^2$
Work: $W = F\,\Delta x\cos\theta$ $\quad W = \tau_z\,\Delta\theta$
Change in kinetic: $\Delta K = W$

Gravitational Potential: $U_\mathrm{G} = mg\,y$
Elastic Potential: $U_\mathrm{Sp} = \frac{1}{2}k\,x^2$

Conservation of Energy:

$$\underbrace{K+U}_{\text{before}} = \underbrace{K+U}_{\text{after}} + \Delta E_\mathrm{Th}$$

Energy = Power × Time ($\Delta E = P \times \Delta t$)
Efficiency ($\mathscr{E}$): $E_\mathrm{out} = \mathscr{E} \times E_\mathrm{in}$

WAVES:

Wavelength: $\lambda = \Delta x/\mathrm{rep}$
Period: $T = \Delta t/\mathrm{rep}$
Frequency: $f = \mathrm{rep}/\Delta t = 1/T$

$$\lambda = v/f$$

Power = Intensity × Area ($P = I \times A$)
Energy = Intensity × Area × Time ($\Delta E = I \times A \times \Delta t$)

Level: $\beta = (10\,\mathrm{dB})\log(I/I_0)$, where $I_0 = 10^{-12}\mathrm{W/m^2}$
$I = I_0 \times 10^{\beta/10\,\mathrm{dB}}$
Attenuation: $\Delta\beta = -\alpha \times \Delta x$,
where $\Delta\beta = (10\,\mathrm{dB})\log(I_2/I_1)$

ELECTRICITY:

Charge: Q
Charge = Current × Time ($\Delta Q = I \times \Delta t$)
Energy = Voltage × Charge ($\Delta E = \Delta V \times \Delta Q$)
Power = Voltage × Current ($P = \Delta V \times I$)

Ohm's Law: $\Delta V = IR$
Equivalent resistance: $R_\mathrm{eq} = \mathscr{E}/I$
Series: $R_\mathrm{eq} = R_1 + R_2$
Parallel: $(R_\mathrm{eq})^{-1} = (R_1)^{-1} + (R_2)^{-1}$

Power: $P = I\,\Delta V = I^2R = (\Delta V)^2/R$

UNITS:

Force: 1 newton = $1\,\mathrm{N} = 1\,\mathrm{kg\cdot m/s^2}$
Pressure & Stress: 1 pascal = $1\,\mathrm{Pa} = 1\,\mathrm{N/m^2}$
Energy: 1 joule = $1\,\mathrm{J} = 1\,\mathrm{N\cdot m} = 1\,\mathrm{kg\cdot m^2/s^2}$
Power: 1 watt = $1\,\mathrm{W} = 1\,\mathrm{J/s} = 1\,\mathrm{N\cdot m/s} = 1\,\mathrm{kg\cdot m/s^3}$
Intensity: $\mathrm{W/m^2}$

Volume of one litre: $1\,\mathrm{L} = (10\,\mathrm{cm})^3 = 10^{-3}\,\mathrm{m^3}$

Frequency: 1 hertz = 1 Hz = 1 rep/s
Angle: $360° = 1\,\mathrm{rev} = 2\pi\,\mathrm{rad}$

Charge: 1 coulomb = 1 C
Current: 1 ampere = 1 A = 1 C/s
Voltage: 1 volt = 1 V = 1 J/C
Resistance: 1 ohm = $1\,\Omega$ = 1 V/A

CONSTANTS:

Magnitude of gravitational field: $g = 9.81\,\mathrm{N/kg}$
One hour: $1\,\mathrm{h} = 3\,600\,\mathrm{s}$

The nutritional calorie: $1\,\mathrm{Cal} = 4\,184\,\mathrm{J}$
Heat capacity of water: $\mathscr{C} = 4\,184\,\mathrm{J/kg\cdot C°}$
Density of water: 1 L has a mass of 1 kg = 1 000 gram.
Kilowatt-hour: $1\,\mathrm{kWh} = 1000\,\mathrm{W} \times 3\,600\,\mathrm{s} = 3.6\,\mathrm{MJ}$

Charge of one proton: $+1.602 \times 10^{-19}\,\mathrm{C}$.
Milliamp-hour: $1\,\mathrm{mAh} = 0.001\,\mathrm{A} \times 3\,600\,\mathrm{s} = 3.6\,\mathrm{C}$.
Avogadro's number: $6.022 \times 10^{+23}\,\mathrm{mol^{-1}}$.

METRIC PREFIXES:

name:	nano	micro	milli		kilo	mega	giga
symbol:	n	µ	m		k	M	G
power:	10^{-9}	10^{-6}	10^{-3}	1	10^{+3}	10^{+6}	10^{+9}

Exception: "centi": 1 centimeter = $1\,\mathrm{cm} = 10^{-2}\,\mathrm{m}$ Example: $432.\,\mathrm{cm} = 4.32\,\mathrm{m}$

Area of circle: $A = \pi r^2$ Surface area of sphere: $A = 4\pi r^2$ Volume of sphere: $V = \frac{4}{3}\pi r^3$