PHYS1121/PHYS1131 – FORMULA AND DATA SHEET

This information will be provided to students in all examinations in the course.

The symbols in formulæ have the conventional meanings.

- **Kinematics**

Constant acceleration: $x = x_o + v_{xo}t + \frac{1}{2}a_x t^2$

$v = v_{xo} + a_x t$

$v_x^2 = v_{xo}^2 + 2a_x(x - x_o)$

Circular motion: $v = r\omega$ $a_c = v^2/r$

- **Dynamics**

Newton's 2nd law $\Sigma\mathbf{F} = \frac{d\mathbf{p}}{dt}$ $\Sigma\mathbf{F} = m\mathbf{a}$

Hooke's law $F = -kx$

Work $dW = \mathbf{F}.d\mathbf{x}$

Power $P = \frac{dW}{dt} = F\,v\cos\theta$

Kinetic Energy $K = \frac{1}{2}mv^2$

Potential Energy $U(x) = -\int F dx$ $F = -\frac{dU}{dx}$

$U = mgh$, $U = \frac{1}{2}kx^2$

Momentum $\mathbf{p} = m\mathbf{v}$

Centre of mass $\mathbf{r}_{cm} = \frac{\Sigma m_i \mathbf{r}_i}{M}$ or $= \frac{\int \mathbf{r} dm}{M}$

- **Rotational dynamics**:

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

$\tau = r F \sin\theta = I\alpha$

$I = \sum_i m_i r_i^2$ or $= \int r^2 dm$

$\mathbf{L} = \mathbf{r} \times \mathbf{p}$

$L = mr\,v\sin\theta$ or $= I\omega$

$W = \int \tau\, d\theta$

$K = \frac{1}{2}I\omega^2$

$I = \frac{2}{5}MR^2$ *solid sphere*

- **Thermal Physics**:

$\frac{\Delta L}{L} = \alpha\,\Delta T$

$\frac{\Delta V}{V} = \beta\Delta T$

$Q = mc\,\Delta T$

$Q = mL$

$PV = nRT = Nk_BT$

$\bar{\varepsilon} = \frac{3}{2}k_BT = \frac{1}{2}m\overline{v^2}$

$U = N\bar{\varepsilon} = \frac{3}{2}Nk_BT$

$PV^\gamma = \text{constant}$

$H = \kappa A \frac{dT}{dx}$

$dW = -P\,dV$

$\Delta E_{int} = Q + W$

- **Gravitation**

Gravitation $|F| = \frac{Gm_1m_2}{r^2}$ $U = -\frac{Gm_1m_2}{r}$

Keppler's 2nd Law $\frac{dA}{dt} = \frac{L}{2M_\rho}$

Keppler's 3rd Law $T^2 = \left(\frac{4\pi^2}{GM_s}\right)a^3$

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- Waves and Oscillations

$v = \sqrt{\frac{T}{\mu}}$ $\quad$ $v = \sqrt{\frac{B}{\rho}}$

$v = \lambda f$ $\quad$ $\omega = 2\pi f$

$k = \frac{2\pi}{\lambda}$ $\quad$ $T = \frac{1}{f}$

$F = -kx$ $\quad$ $\Delta P_{max} = v\rho\omega S_{max}$

$T = 2\pi\sqrt{\frac{l}{g}}$ $\quad$ $\omega^2 = k/m$

$f = \frac{1}{2\pi}\sqrt{k/m}$

$\beta = 10\log_{10}\left(\frac{I}{I_0}\right)$ $\quad$ $I_0 = 10^{-12}\,\mathrm{Wm}^{-2}$

$I = \frac{\text{power}}{\text{area}}$ $\quad$ $I = \frac{P}{4\pi r^2}$

$I = \frac{1}{2}\rho v\omega^2 S_{max}^2$ $\quad$ $P = \frac{1}{2}\mu v\omega^2 A^2$

$f' = f\left(\frac{c \pm v_0}{c \mp v_s}\right)$ $\quad$ $f_{beat} = f_1 - f_2$

$y = A\sin(kx - \omega t + \phi)$

$f_n = \frac{n}{2L}\sqrt{\frac{T}{\mu}}$ $\quad$ $\lambda_n = \frac{\lambda}{n}$

Trigonometric identities:

$\sin A \pm \sin B = 2\sin\left(\frac{A \pm B}{2}\right)\cos\left(\frac{A \mp B}{2}\right)$

$\cos A + \cos B = 2\cos\frac{A+B}{2}\cos\frac{A-B}{2}$

$\cos A - \cos B = -2\sin\frac{A+B}{2}\sin\frac{A-B}{2}$

$\sin^2\theta + \cos^2\theta = 1$

cosine rule: $a^2 = b^2 + c^2 - 2bc\cos\theta$

$\sin(A \pm B) = \sin A\ \cos B \pm \cos A \sin B$

$\cos(A \pm B) = \cos A\ \cos B \mp \sin A \sin B$

DATA SHEET

1 atmosphere (Standard air pressure)	1.01×10^{5} Pa
Latent heat of vaporisation of water at constant pressure	2.30×10^{6} J kg^{-1}
Latent heat of fusion of ice, L_f	3.33×10^{5} J kg^{-1}
Avogadro's constant, N	6.022×10^{23} particles/mole
Charge on electron, e	1.602×10^{-19} C (negative)
Gas constant, R	8.314 J K^{-1} $mole^{-1}$
	0.0821 litre-atm K^{-1} $(g\ mol)^{-1}$
1 amu ≡ 1 u	1.66×10^{-27} kg
Atomic mass unit , u	1.661×10^{-27} kg = 931.5 MeV/c^2
Mass of electron, m_e	9.109×10^{-31} kg = 5.486×10^{-4} u
Mass of neutron, m_n	1.675×10^{-27} kg = 1.0087 u
Mass of proton, m_p	1.673×10^{-27} kg = 1.0073 u
Planks constant, h	6.63×10^{-34} Js
Boltzmann's constant, k_B	1.381×10^{-23} JK^{-1}
Earth's gravitational acceleration, g	9.80 m s^{-2}
Speed of light, c	2.998×10^{8} m s^{-1}
Universal gravitation constant, G	6.673×10^{-11}N m^2 kg^{-2}
Density of water, ρ	1.00×10^{3} kg m^{-3}
Mass of Earth	5.98×10^{24} kg
Average radius of Earth	6.37×10^{6} m
Mass of Moon	7.36×10^{22} kg
Average Earth-Moon distance	3.84×10^{8} m
Mass of Sun	1.99×10^{30} kg
Radius of Sun	6.96×10^{8} m
Average Earth-Sun distance	1.496×10^{11} m
Volume of 1 g mole ideal gas at 101.3 kPa (1 atm) and	
at 0°C (273 K)	$2.241\times10^{-2}m^3$
at 25°C (298 K)	$2.447\times10^{-2}m^3$
Specific Heat of Water	4186 J/kg °C
Mechanical equivalent of heat, 1 cal	4.186 J
Stefan's Constant, σ	5.67×10^{-8} $Js^{-1}m^{-2}K^{-4}$
Wien's Constant, B	2.898×10^{-3} m.K.
1 eV	1.60×10^{-19} J
Reference Intensity, I_o, (near the threshold of hearing),	1 x 10^{-12} W m^{-2}