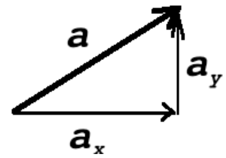
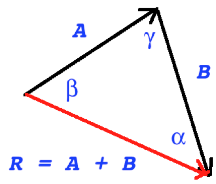
PY106 EQUATION SHEET I

A vector and its components:

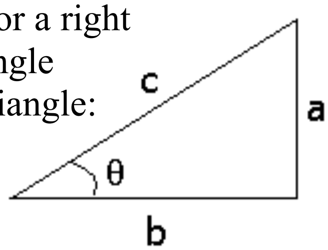


For ANY triangle:



$$R^2 = A^2 + B^2 - 2|AB|\cos\gamma \qquad \frac{|A|}{\sin\alpha} = \frac{|B|}{\sin\beta} = \frac{|R|}{\sin\gamma}$$

For a right angle triangle:



$$a^2 + b^2 = c^2 \qquad c = \sqrt{a^2 + b^2} \qquad a = \sqrt{c^2 - b^2}$$

$$\sin\theta = \frac{a}{c} \qquad \cos\theta = \frac{b}{c} \qquad \tan\theta = \frac{a}{b} \qquad (\sin\theta)^2 + (\cos\theta)^2 = 1$$

Adding vectors: $\vec{a} + \vec{b} = \vec{c}$ => $a_x + b_x = c_x$ and $a_y + b_y = c_y$

Quadratic equation: If $ax^2 + bx + c = 0$, $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Circumference: C = 2πr **Area of a circle: A = πr^2** **Area of a triangle: A = 0.5*hb***

Conversion factors and prefixes: m = 10^{-3}; μ = 10^{-6}; n = 10^{-9}; p = 10^{-12}; k = 10^3; M = 10^6; G = 10^9

1 m = 100 cm   1 km = 1000 m   1 mi = 1.6 km = 1600 m   1 L = 10^{-3} m^3

1 cm = 10 mm   1 min = 60 s   1 h = 60 min   1 kg = 1000 g

1 inch = 2.54 cm   1 ft = 12 inch 360^0 = 2π rad = 1 rev

General Definitions

Average Speed:

$$v_{av\,sp} = \frac{L}{\Delta t}$$ **(*L* - distance)**

Average Velocity:

$$\vec{v}_{av\,vel} = \frac{\Delta\vec{x}}{\Delta t}$$ ($\Delta\vec{x}$ - displacement)

Average Acceleration: $$\vec{a}_{av} = \frac{\Delta\vec{v}}{\Delta t} = \frac{\vec{v}_f - \vec{v}_i}{\Delta t}$$

"Instantaneous" = "slope"

Constant Acceleration Equations for 1-D Motion

$$x = x_o + v_{ox}t + \tfrac{1}{2}a_x t^2 \qquad v = v_{ox} + a_x t \qquad v_x^2 = v_{ox}^2 + 2a_x(x - x_o) \qquad v_{ave} = (v_0 + v_f)/2$$

Newton's Laws

$\vec{F}_{Net}$ **definition:** $\vec{F}_{Net} = \vec{F}_1 + \vec{F}_2 + \ldots$ **Translational Equilibrium:** rest and $\vec{F}_{Net} = \vec{F}_1 + \vec{F}_2 + \ldots = 0$

Newton's Second Law: $\Sigma \boldsymbol{F} = m\boldsymbol{a}$ or $\vec{F}_{net} = m\vec{a}$ Newton's Third Law: $\boldsymbol{F}_{12} = -\boldsymbol{F}_{21}$

Weight: $\boldsymbol{W} = mg$ Momentum: $\vec{p} = m\vec{v}$ $\vec{F}\Delta t = \Delta\vec{p}$

Energy and Work:

Work (constant force): $W = Fd\cos\theta$ (θ is the angle between the force and displacement)

Kinetic Energy: translational $KE = K_{tr} = \frac{1}{2}mv^2$ rotational $K_{rot} = \frac{1}{2}I\omega^2$

Potential Energy: Gravitational (y-axis is *UP*): $U_G = mgy$ Elastic: $U_E = \frac{1}{2}kx^2$

Energy Conservation: Master equation: $U_i + K_i + W_{nc} = U_f + K_f$ where W_{nc} is work done by non-conservative forces

Work done by a conservative force: $W_{ConF} = U_1 - U_2$

Work – Kinetic Energy theorem: $K_f - K_i = W_{total} = W_{net} = W_1 + W_2 + \ldots$

PY106

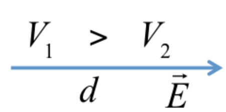
Constants: $k = \dfrac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ \mathrm{Nm^2/C^2}$ $\varepsilon_0 = 9 \times 10^{-12}\ \mathrm{C^2/(Nm^2)}$ $e = 1.60 \times 10^{-19}\ \mathrm{C}$

Magnitude of the Coulomb Force: $|F| = \dfrac{k|q_1q_2|}{r^2}$ Force-Field connection: $\vec{F} = q\vec{E}$

Magnitude of the Electric Field of a charge q: $|E| = k|q|/r^2$ $\vec{E}_{NET} = \vec{E}_1 + \vec{E}_2 + \ldots$

Potential of a charge: $V = \dfrac{kq}{r}$ $V_{Net} = V_1 + V_2 + \ldots$

Potential Difference for a uniform field: $|\Delta V| = |E|d$



$V_1 = V_2 + |E|d$

Potential Energy for two charges: $U = \dfrac{k\,q_1\,q_2}{r}$ Potential Energy of a charge in E-field: $U = qV$

Work done by electric field: $W_{ElecF} = U_1 - U_2 = q(V_1 - V_2)$

Electric field in a dielectric: $E = \frac{E_{vac}}{\kappa}$ Electric field in a parallel plate capacitor: $E = \frac{Q}{\kappa \varepsilon_0 A}$

Capacitance: $C = \frac{Q}{|\Delta V|}$ $C = \frac{\kappa \varepsilon_o A}{d}$ $U = \frac{Q|\Delta V|}{2} = \frac{Q^2}{2C} = \frac{C(\Delta V)^2}{2}$

Capacitors in parallel: $C_{eq} = C_1 + C_2 + \ldots$ $Q_{total/eq} = Q_1 + Q_2 + \ldots$

Capacitors in series: $\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \ldots$ $\Delta V_{total/eq} = \Delta V_1 + \Delta V_2 + \ldots$

Electric current:

$I = \frac{\Delta Q}{\Delta t}$ Ohm's Law: $I = \frac{|\Delta V|}{R}$ Resistance and resistivity: $R = \frac{\rho L}{A}$

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

Resistors in parallel: (Junction rule) $I_{total} = I_1 + I_2 + \ldots$ $\frac{1}{R_{eq}} = \frac{1}{R_2} + \frac{1}{R_3} + \ldots$

Resistors in series: $\Delta V_{total} = \Delta V_1 + \Delta V_2 + \ldots$ $R_{eq} = R_1 + R_2 + R_3 + \ldots$