"I'm totally allowed to have this on my quiz!"
-Fact Robot B25Q57F

1 Unit on units (and symbols)

1.1 Base Units

q Charge: Coulomb
$$\mathrm{C}$$

$\vec{r}$ Length: meter
$$\mathrm{m}$$

T Temperature: Kelvin
$$\mathrm{K}$$

m Mass: kilogram
$$\mathrm{kg}$$

t Time : Second
$$\mathrm{s}$$

1.2 Derived Units

$\vec{F}$ Force: Newton
$$\mathrm{N} = \frac{\mathrm{kg} \cdot \mathrm{m}}{\mathrm{s}^2}$$

E Energy: Joule
$$\mathrm{J} = \mathrm{N} \cdot \mathrm{m} = \frac{\mathrm{kg} \cdot \mathrm{m}^2}{\mathrm{s}^2}$$

P Power: Watt
$$\mathrm{W} = \frac{\mathrm{J}}{\mathrm{s}} = \frac{\mathrm{kg} \cdot \mathrm{m}^2}{\mathrm{s}^3}$$

V Voltage: Volt
$$\mathrm{V} = \frac{\mathrm{J}}{\mathrm{C}} = \mathrm{A} \cdot \Omega$$

A Current: Ampere
$$\mathrm{A} = \frac{\mathrm{C}}{\mathrm{s}}$$

R Resistance: Ohm
$$\Omega = \frac{\mathrm{J} \cdot \mathrm{s}}{\mathrm{C}^2}$$

1.3 Constants

$$g = 9.8\ \frac{\mathrm{m}}{\mathrm{s}^2}$$
$$G = 6.67 \times 10^{-11}\ \frac{\mathrm{N} \cdot \mathrm{m}^2}{\mathrm{kg}^2}$$
$$k = 9 \times 10^9\ \frac{\mathrm{N} \cdot \mathrm{m}^2}{\mathrm{C}^2}$$
$$c = 3.0 \times 10^8\ \frac{\mathrm{m}}{\mathrm{s}}$$
$$\rho_w \approx\ 1 \frac{\mathrm{g}}{\mathrm{cm}^3}$$
$$\rho_{air} \approx\ 1 \frac{\mathrm{kg}}{\mathrm{m}^3}$$

2 20 simple formulas that will improve your physics!

2.1 Kinematics

$$\vec{v} = \vec{v}_0 + \Delta\vec{v} = \vec{v}_0 + \vec{a}_0 t$$

$$\vec{r} = \vec{r}_0 + \Delta\vec{r} = \vec{r}_0 + \vec{v}_0 t + \frac{1}{2}\vec{a}_0 t^2$$

2.2 Forces

$$\vec{F}_{net} = m_{_{tot}}\vec{a}$$

$$\vec{F}_{net} = \sum_{i=1}^{N} \vec{F}_i$$

$$\vec{F}_{f,k} = -F_N \mu_k \hat{v}$$

2.3 Energy/Power

$$\Delta E = W$$

$$W = \vec{F} \cdot \Delta\vec{r} \quad \text{(Conservative force)}$$

$$W = FD \quad \text{(Non} - \text{conservative parallel force)}$$

$$P = \frac{W}{t} = \frac{\Delta E}{t}$$

$$E_k = \frac{1}{2}mv^2 = \frac{1}{2}I\omega^2$$

$$E_g = mgh$$

2.4 Momentum

$$\Delta\vec{p}_{tot} = \vec{0}$$

$$\vec{p} = m\vec{v}$$

$$\Delta\vec{p} = \vec{F}t$$

2.5 Gravity

$$\vec{F}_g = -\frac{GMm}{r^2}\,\hat{\boldsymbol{\imath}} \quad (\hat{\boldsymbol{\imath}} \text{ is the direction of the line between the masses})$$

$$\vec{F} = m\vec{g}$$

$$E_g = -\frac{GMm}{R}$$

2.6 Electrostatics

$$\vec{F}_e = \frac{kq_1q_2}{r^2}\,\hat{\boldsymbol{\imath}} \quad (\hat{\boldsymbol{\imath}} \text{ is the direction of the line between the charges})$$

$$\vec{E} = \frac{kq_1}{r^2}\,\hat{\boldsymbol{\imath}} \quad (\hat{\boldsymbol{\imath}} \text{ is the direction of the line between the charges})$$

2.7 Oscillations and Springs

$$T = 2\pi\sqrt{\frac{L}{g}}$$

$$T = 2\pi\sqrt{\frac{m}{k}}$$

$$r(t) = A\cos(\omega t + \phi)$$

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

$$a(t) = -A\omega^2\cos(\omega t + \phi)$$

$$\vec{F}_s = -k\Delta\vec{r}$$

$$E_{sys} = \frac{1}{2}k(\Delta r)^2 + \frac{1}{2}Mv^2$$

2.8 Rotational Dynamics

$$\vec{\tau} = \vec{r} \times \vec{F}$$

$$\vec{\tau} = I\vec{\alpha}$$

$$\Delta\vec{L}_{tot} = \vec{0}$$

$$\vec{L} = \vec{r} \times \vec{p} = I\vec{\omega}$$

$$\Delta\vec{L} = \vec{\tau}t$$

$$a_c = \frac{v^2}{R}$$

$$P = \vec{F} \cdot \vec{v}$$

2.9 Rotational Kinematics

$$\vec{\omega} = \vec{\omega}_0 + \vec{\alpha}t$$

$$\vec{\theta} = \vec{\theta}_0 + \vec{\omega}_0 t + \frac{1}{2}\vec{\alpha}t^2$$

$$\vec{v} = \vec{\omega} \times \vec{r}$$

$$\vec{a} = \vec{\alpha} \times \vec{r}$$

2.10 Fluids

$$P = \frac{F}{A}$$

$$P = \rho g h$$

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$$

$$A_1 v_1 = A_2 v_2$$

$$P_g = P - P_{atm}$$

2.11 Some Moments of Inertia

All of these are taken with the axis of rotation through the center unless otherwise noted.

- Parallel axis theorem: $I_{axis} = I_{cm} + MD^2$
- Point: MR^2
- Solid Sphere: $\frac{2}{5}MR^2$
- Thin Spherical Shell: $\frac{2}{3}MR^2$
- Disk or cylinder: $\frac{1}{2}MR^2$
- Rod (axis at one end, $\perp$ to rod): $\frac{1}{3}MR^2$
- Rod (axis in center, $\perp$ to rod): $\frac{1}{12}MR^2$

3 Arrows, and how they make life better

For this section let $\vec{A} = A_x\hat{\mathrm{x}} + \mathrm{A_y}\hat{\mathrm{y}} + \mathrm{A_z}\hat{\mathrm{z}}$ and let $\vec{B} = B_x\hat{\mathrm{x}} + \mathrm{B_y}\hat{\mathrm{y}} + \mathrm{B_z}\hat{\mathrm{z}}$. These are arbitrary vectors and can be replaced with any vectors that appear in physics formula. Any special conditions for the formula to be true are given at the beginning of the subsection. Unless otherwise noted θ is the angle between the vectors.

3.1 Vector equality

$$\vec{A} = \vec{B} \quad \Longrightarrow \begin{cases} A_x = B_x \\ A_y = B_y \\ A_z = B_z \end{cases}$$

3.2 Vector Components

For this subsection, assume that $A_y = 0$. Essentially this means that $\vec{A}$ points somewhere in the $x - z$ plane. Let θ be the angle between $\vec{A}$ and the x axis.

$$A_x = \vec{A} \cdot \hat{\mathrm{x}} = ||\mathrm{A}|| \cos(\theta)$$

$$A_z = \vec{A} \cdot \hat{\mathrm{z}} = ||\mathrm{A}|| \sin(\theta)$$

3.3 Dot Product

$$||\vec{A}||^* = A = \sqrt{\vec{A} \cdot \vec{A}} = \sqrt{A_x^2 + A_y^2 + A_z^2}$$

$$\vec{A} \cdot \vec{B} = A_xB_x + A_yB_y + A_zB_z = ||A||\ ||B|| \cos(\theta)$$

3.4 Cross Product

$$||\vec{A} \times \vec{B}|| = ||A||\ ||B|| \sin\theta$$

$$\vec{A} \times \vec{B} = -\vec{B} \times \vec{A}$$

$$\vec{A} \times \vec{B} = (A_yB_z - A_zB_y)\hat{\mathrm{x}} + (\mathrm{A_zB_x} - \mathrm{A_xB_y})\hat{\mathrm{y}} + (\mathrm{A_xB_y} - \mathrm{A_yB_x})\hat{\mathrm{z}}$$

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*Physicists will nearly always just use A instead of $||\vec{A}||$. This makes mathematicians cry. Physicists harvest these tears to make smoothies.