The Definitive Physics Definition List

Engineer(s) of Dubious Quality

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1 Measurements

Express errors/uncertainties to 1 s.f. and write the measured value to the same decimal place as its error/uncertainty

Systematic Error	An error that occurs consistently more or consistently less than the actual reading.
Random Error	An error that occurs as a scattering (or spreading) of readings about the average or mean value of the measurements.
Precision	The ***reproducibility*** of a measurement. Repeated measurements which are very close to one another are precise measurements. Thus an experiment which has ***small random errors*** (i.e. small spread of readings) is said to have ***high precision***.
Accuracy	The ***agreement*** between the measured value and the true or accepted value of a quantity. An experiment which has ***small systematic errors*** is said to have ***high accuracy***. The ***average value*** is close to the true value.
Vector Quantity	A quantity that has a ***magnitude and direction***.
Scalar Quantity	A quantity that has a ***magnitude only***.

2 Kinematics

We define a coordinate system with defined reference positive directions and we assume constant acceleration.

Displacement	$\mathbf{s}$	The distance travelled in a stated direction from a reference point.
Velocity	$\mathbf{v} = \frac{d\mathbf{s}}{dt}$	The rate of change of displacement with respect to time.
Speed	$v = \lvert\mathbf{v}\rvert = \left\lvert\frac{d\mathbf{s}}{dt}\right\rvert$	The rate of change of distance travelled with respect to time.
Acceleration	$\mathbf{a} = \frac{d\mathbf{v}}{dt} = \frac{d^2\mathbf{s}}{dt^2}$	The rate of change of velocity with respect to time.

3 Dynamics

3.1 Newton's Laws of Motion

1st Law	A body will continue in its ***state of rest***, or ***move*** at ***constant speed in a stright line*** unless an ***external resultant force*** acts on it.
$\rightarrow$ Inertia	The resistance to change in the state of motion of an object
$\rightarrow$ Mass	A property of that determines the objects inertia.
2nd Law	The ***rate of change of linear momentum*** of a body is ***directly proportional*** to the resultant force acting on it, and its direction is in the ***same direction*** as this resultant force. The ***force acting on an object*** is defined as the ***rate of change of linear momentum*** of an object. $$\mathbf{F} \propto \frac{d\mathbf{p}}{dt},\ F = m\mathbf{a} \text{ (if constant mass)}$$
3rd Law	If body A exerts a force on body B, then body B will exert an ***equal and opposite*** force on body A. *Note:* Action-Reaction Pairs act on different bodies and are of the same nature.
Weight	The gravitational force acting on the object.
Weightlessness	There is no contact force acting on the object. *A body experiences apparent weightlessness when the resultant force acting on it is its weight, or it is undergoing freefall.*

3.2 Momentum

Linear Momentum	$\mathbf{p} = m\mathbf{v}$	The product of an object's mass and its velocity.
Impulse	$\mathbf{J} = \int_{t1}^{t2} \mathbf{F}\,dt = P_f - P_i$	The product of the average force acting on an object and the time interval that the force is being applied.
Principle of Conservation of Linear Momentum	The total momentum of the system is a constant when no external resultant force acts on it.	

4 Forces

Pressure due to Fluid	$\Delta P = h\rho g$	The force acting per unit area by the fluid on a body submerged at a depth in the fluid.
Upthrust	$U = m_f g = \rho V_{dis} g$	The ***net force exerted by a fluid*** on a body submerged in the fluid.
Principle of Floatation	$mg = U = \rho V_{dis} g$	This holds true for an object floating in equillibrium in a fluid.
Drag	$\mathbf{F_D} = k\mathbf{v}$ (Laminar Flow)	It is the force resisting an object ***moving relative to a fluid***. It always ***opposes*** motion, and its magnitude is ***dependent on the velocity*** of the object.
Moment of a force (Torque)	$\boldsymbol{\tau} = \mathbf{r} \times \mathbf{F}$	Moment of a force about a point (the pivot) is the ***product*** of the magnitude of the force and the ***perpendicular distance*** of the ***line of action*** of the force to the point.
Couple	A couple always consists of 2 parallel forces which are equal in magnitude and opposite in direction (their lines of action fo not coincide)	
Torque of a couple	The ***product*** of the ***magnitude of one of the forces*** of the couple and the ***perpendicular distance between the forces.***	
Center of gravity of a body	It is the point at which the weight of the body appears to act.	

4.1 Equilibrium of Forces

For a rigid body to be in static equilibrium, 2 conditions must be satisfied:

1. **Translational equilibrium**
The **net external** force acting on the body is zero.

$$\sum F = 0$$

2. **Rotational Equilibrium**
The **net torque** on the body about **ANY point** is zero.

$$\sum \tau = 0$$

For a 3-forces system in static equilibrium, the 3 forces for *a closed vector triangle.* For 3 forces acting on an *extended body* in static equilibrium, the lines of action of the 3 forces *must intersect at a common point* unless the 3 forces are parallel.

5 Work, Energy, and Power

Principle of Conservation of Energy	Energy can be ***converted*** from one form to another, but it ***cannot be created or destroyed***. The ***total energy*** of an ***isolated*** system is constant

Work done by a Force	$W = \int_{x1}^{x2} \mathbf{F} \cdot d\mathbf{x}$	The product of the magnitude of the force F and the displacement s in the direction of the force.
Total Mechanical Energy	$\sum \text{KE} + \sum \text{PE}$	The total mechnical energy of a system is the sum of all types of kinetic energy and potential energy.
Kinetic Energy	$E_k = \frac{1}{2}mv^2$	Kinetic energy of a body is a measure of the energy possessed by the body by virtue of its motion.
Potential Energy	–	The amount of work that was done on a body to give it that position. It is a measure of the energy possessed by the body by virtue of its position or the arrangement of the system that it is part of. [There are 3 types: Elastic, Gravitational and Electrical]
Power	$P = \dfrac{dW}{dt} = Fv$	Power is the rate at which work is done. When a force acts on a body that is moving with velocity v, in the direction of the force, it delivers power to the body at the rate given by $P = Fv$.

6 Circular Motion

Always write "The _________ forces provide the centripetal force".

Angular Displacement	θ	Angle swept from a reference point.
Angular Velocity	$\omega = \frac{d\theta}{dt} = \frac{2\pi}{T} = 2\pi f$	Rate of change of angular displacement with respect to time.
Period	$T = \frac{1}{f}$	Time taken for one complete revolution.
Linear/Tangential Speed	$v = \frac{2\pi r}{T} = r\omega$	*(No need to know definition)*

6.1 Uniform Circular Motion

Conditions: ω constant, r constant

Uniform Circular Motion	It is the motion of an object travelling at constant (uniform) speed in a circular path.
Centripetal Acceleration/ Centripetal Force	The centripetal acceleration/force is directed ***radially inward*** towards the centre of the circular path. The direction of the centripetal acceleration/force is continuously changing. $$\sum a = a_{net} = a_c = \frac{v^2}{r} = r\omega^2 = v\omega$$ No acceleration/force in the tangential direction. $\Rightarrow$ No work done.

7 Gravitation

The ‘G’s in the following left column stands for ‘Gravitation’, or ‘Gravitational’.

Newton’s Law of G	$F_g = G\dfrac{m_1 m_2}{r^2}$	Gravitational force between 2 objects is directly proportional to the product of their masses, and inversely proportional to the square of the distances between them.
G Field Strength	$g = \dfrac{F_g}{m} = G\dfrac{M}{r^2}$	The GFS g at a point in a gravitational field is the gravitational force per unit mass acting on a small mass placed at that point.
G Field	–	A region of space surrounding a body possessing mass, in which any other body that has mass will experience a force of attraction.
G Potential	$\phi = \dfrac{U}{m} = -G\dfrac{M}{r}$ $g = -\dfrac{d\phi}{dr}$	Work done per unit mass by an external force in bringing a small mass from inifinity to that point in a gravitational field without a change in kinetic energy.
G Potential Energy	$U = -G\dfrac{m_1 m_2}{r}$ $F_g = -\dfrac{dU}{dr}$	Work done by an external force in bringing the mass from the mass from infinity to that point in a gravitational field without a change in kinetic energy.
Geostationary Orbit		Satellite in orbit is above a fixed point on Earth, and appears stationary to observer on Earth.

8 Oscillations

Simple Harmonic Motion	$a = -\omega^2 x$	A body oscillating with SHM has acceleration that is directly proportional to the displacement from equilibrium and is in a direction opposite to that of displacement from equilibrium.
Damped Oscillation	–	Oscillation in which the amplitude of the oscillations decreases with time
Resonance	–	Phenomenon where the maximum amplitude of an object driven to oscillate is achieved when the driver frequency is equal to the natural frequency.

9 Waves and Superposition

Progressive Waves	Disturbance/Vibration which **propagates**, carrying **energy without physically transferring** the wave particle
$\rightarrow$ Transverse Waves	Progressive wave in which particles or fields oscillate perpendicular to direction of wave propagation
$\rightarrow$ Longitudinal Waves	Progressive wave in which particles oscillate parallel to direction of wave propagation
Intensity	Power per unit area $$E \propto A^2 \Rightarrow I \propto A^2$$
Polarisation	Restriction of a geometrical orientation such that the vibrations occur in a single plane
Principle of Superposition	When 2 or more waves of the **same type** superpose, the **displacement** of a **resultant wave at any point** is the **vector sum** of the displacements of the individual waves at that point at that instant.
Stationary/Standing Waves	Formed when 2 **similar** waves of **same speed, frequency and amplitude** travelling towards each other in **opposite** directions superpose.
Interference	The superposing of 2 or more waves to give a resultant wave whose displacement at every point at any time is give by the Principle of Superposition. $\Rightarrow$ Conditions: (i) Same kind of waves; (ii) overlap
$\rightarrow$ Observable Interference	• Same type, overlap • Coherence • Roughly same Amplitude • Unpolarised or polarised in the same plane Constructive: Oscillation at that point has max resultant amp and max int. Destructive: Oscillation at that point has min resultant amp and min int.
Diffraction	Spreading of waves into **“geometrical” shadow** after passing through an aperture or around an obstacle as a result of a **redistribution of energy**.

10 Thermal Physics

Temperature	T	The average kinetic energy the molecules in a system possess.
Heat	Q	Transfer of thermal energy from regions of higher to lower temperature.
Thermal Equilibrium		2 objects in thermal contact with no net exchange of heat.
Kelvin Scale		Absolute temperature scale independent of thermometric properties.
Absolute Zero	0K	All molecules possess minimal internal energy.
Specific Heat Capacity	C	Amount of thermal energy per unit substance to increase the temperature of the unit substance by one unit of temperature.
Specific latent heat of fusion	L_f	Amount of **thermal energy per unit mass** to convert the substance from solid to liquid without any change in temperature.
Specific latent heat of vaporisation	L_v	Amount of **thermal energy per unit mass** to convert the substance from liquid to gas without any change in temperature.
Internal Energy	U	Sum of microscopic random kinetic energy and microscopic potential energy of molecules in system. For ideal gases: $$U = \frac{3}{2}\, nRT$$

10.1 Laws of Thermodynamics

0^{th}	If two systems are in thermal equilibrium with a third system, they are in thermal equilibrium with each other.
1^{st}	Increase in internal energy of system is sum of heat absorbed by system and work done on system. $$\Delta U = Q + W_{on}$$

We need not know the 3^{rd} and 4^{th} laws.

10.2 PV Graphs

We assume, for the following, that the arrow points towards the positive-V direction.

Isobaric	Constant Pressure	$W_{on} < 0$, $\Delta U > 0$
Isochoric	Constant Volume	$W_{on} = 0$, $\Delta U > 0$
Isothermal	Constant Temperature	$W_{on} < 0$, $\Delta U = 0$
Adiabatic	Thermally Insulated	$W_{on} < 0$, $Q = 0$
Cyclic	Start and end at the same state	$\Delta U = 0$

11 Electric Fields

Electric Field	$E = \dfrac{Q}{4\pi\varepsilon_0 r^2}$	**Electric force per unit charge** acting on small positive test charge at that point
Coulomb's Law	$F_E = \dfrac{\lvert Q_1\rvert\lvert Q_2\rvert}{4\pi\varepsilon_0 r^2}$	Magnitude of the electric force between 2 point charges is directly proportional to the product of the magnitude of their charges and inversely proportional to square of their distance $F_E = qE$
Electric Potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$	**Work done per unit charge** by external force to bring small positive test charge from infinity to that point in an electric field without change in kinetic energy
Electric Potential Energy	$U = \dfrac{Q_1 Q_2}{4\pi\varepsilon_0 r}$	**Work done** by external force to bring small positive test charge from infinity to that point in an electric field without change in kinetic energy $U = qV$

12 Current of Electricity

13 DC Circuits

14 EM and EMI

15 Alternating Current

16 Quantum Physics

17 Lasers and Semiconductors

18 Nuclear Physics

Good Luck! Don't Panic.