Physics: Quick reference

vishvAs vAsuki

January 25, 2016

See [1].

Part I
Movement, forces, work, energy

1 Kinematics

Displacement s: a vector. Mass m, time t. Speed, velocity $v = \frac{ds}{dt}$, momentum = mv.

2 Mechanics

Acceleration $a = \frac{dv}{dt}$.

2.1 Force

F = ma; so the rate of change of momentum. A vector too.

Forces occur in pairs: Action, reaction; when one body exerts a force on another, an equal force is exerted by that other body on it.

Conservation of momentum.

Normal forces, friction.

2.2 Modelling

Simplification, a body as a particle; free body diagrams. Center of mass; center of gravity.

2.3 Circular motion

Perpendicular forces, angular velocity ω, relationship with v, Angular acceleration, torque. The wheel.

3 Forces

3.1 Gravity

3.1.1 Newton's model

The law of gravity: $F = k\frac{m_1 m_2}{r^2}$. Usually accurate enough in daily life.

Drawbacks There is instantaneous action at a distance. But, according to special theory of relativity, no information can be transmitted faster than the speed of light; but if newton's law was an accurate model, you would have a gravitational telegraph which can transmit information instantaneously.

3.1.2 Curvature in space-time model

Mass curves space-time. Objects move through this curved space-time.

Gravitational waves An object osscilating in a small pace causes waves in space-time.

Evidence of existance: Massive stars revolving around each other moving closer to each other, loosing energy; matches theoretical prediction of energy dissipated as gravitational waves.

3.1.3 Application of Newton model

Gravity exerted by spherical objects An important special case. If sphere is symmetric in density, it turns out that using point mass located at the center of the sphere is an equally accurate model.

Object falling through air, close to planetary surface Model: Acceleration due to gravity is constant: relative change in r is insignificant.

Air resistance, terminal velocity.

4 Energy

Work $w = \int_a^b f ds$, energy, power. The law of conservation of energy. Potential and keinetic energy. Heat. Escape velocity.

5 Thermodynamics

Molecular motion. Thermodynamic equilibrium is an equivalence relation.

Closed thermodynamic system: Change in the internal energy U = (Enthalpy) Heat supplied + work done.

Work/ energy: PV = nRT. Engines: external combustion and internal combustion. PV curve; cyclical processes, Isothermic and adiabatic processes. Area of a cycle: No perfect engine law. Carnot cycle. Refridgeration and compressors. The total entropy of any isolated thermodynamic system tends to increase over time, approaching a maximum value. Definition of Absolute Zero temperature. Boltzmann distribution of energy at temperature T. Heat: Conduction, convection, radiation. Stefan Boltzmann law. Radiation and absorption spectra.

6 Electricity

Charge: attraction and repulsion. The inverse square law. Lines of force, flux. Find charge inside a surface: Gauss' law. Electric potential energy; electric potential. Potential contours, electric field. Potential difference and force.

6.1 Magnetism

The Hall effect. Magnetic field B as force per unit moving charge: $\mathbf{F} = q\mathbf{v} \times \mathbf{B}$; Relative direction of B. Natural magnets: electric dipoles. Electromagnets. Construction of electric motors and mechanical electricity generators. AC and DC.

7 Quantum mechanics

Matter waves. Quanta: Photoelectric effect.

8 Relativity

Conservation of energy and mass.

Part II
Modelling important situations

9 Periodic Motion

Longitudonal and transverse waves. Frequency, amplitude. Equation for displacement about a point; relationship with circular motion.

10 Hydrodynamics

Incompressible fluids. Bernoulli's law relates density, gravity, fluid velocity. Flight of airplanes and helicopters. Buoyancy. Viscosity.

11 Electric circuits

Electric current, resistivity, conductance. Resistance in a wire related to resistivity, thickness and length: The molecular view. V=IR. Heat generated by resistance. Kirchoff's law of voltage and current in loops: linear equations solved using linear algebra [2]. Capacitors. Capacitance: charge stored, potential difference; plate surface area, distance, dipole moment. Electric transmission using earth and a wire.

12 Electronics

Semiconductors. Silicon, germanium. Positive and negative doping. Diodes: The np junction. .5V to .7V barrier. Forward bias. Reverse bias: breakdown after 5V. Transistors: pnp and npn. Operational Amplifiers.

References

[1] David Halliday, Robert Resnick, and Jearl Walker. *Extended , Fundamentals of Physics, 6th Edition*. Wiley, June 2000.

[2] Gilbert Strang. *Linear Algebra and its applications, 4e*. Thomson Brooks/ Cole, 2006.