Physics Brainstorm File www.EASA66.com

1 Matter

Atoms are composed of 3 types of subatomic particles: see http://en.wikipedia.org/wiki/Atom
electrons, which have a negative charge;
protons, which have a positive charge; and
neutrons, which have no charge. Atoms are the fundamental building blocks of chemistry, and are conserved in chemical reactions. An atom is the smallest particle differentiable as a certain chemical element; when an atom of an element is divided, it ceases to be that element. Only 91 elements have been identified as occurring naturally on Earth.
Each element is unique by the number of protons in each atom of that element. Every atom has a number of electrons equal to its number of protons; if there is an imbalance, the atom is called an ion. Atoms of the same element can have different numbers of neutrons, as long as the number of protons or electrons does not change. Atoms with different numbers of neutrons are called isotopes of a chemical element.
Other elements have been artificially created, but they are usually unstable and spontaneously change into stable natural chemical elements by the processes of radioactive decay. Though only 91 naturally occurring elements exist, atoms of these elements are able to bond into molecules and other types of chemical compounds. Molecules are made up of multiple atoms; For example, a molecule of water is a combination of 2 hydrogen and one oxygen atoms.
An **ion** is an elementary particle or system of elementary particles with a net electric charge.
A neutral atom contains an equal number of protons in the nucleus and electrons in the electron shell. A negatively charged atomic ion, which has gained one or more electrons, is known as an anion, and a positively charged atomic ion, which has lost one or more electrons, is known as a cation. The process of removing or adding charges to a neutral particle is called ionization, the inverse processes are called recombination and detachment. Note that neutral elementary particles cannot be ionized, as they contain no constituent charged particles that can be removed. The formation of free negatively charged atomic ions is non-trivial because an additional electron doesn't experience a Coulomb attraction towards the neutral atom. It is nevertheless possible in many cases, see negative atomic ion.
Ionized atoms or molecules are denoted by superscripting with the number of electrons lost or gained (if more than one) and the sign (+ or -) of the electric charge, e.g. H+ or O2-.
Metals tend to form cations while non-metals tend to form anions e.g. sodium forms cations of Na+ while chlorine forms anions of Cl-.
In science, a **molecule** is the smallest particle of a pure chemical substance that still retains its chemical composition and properties. A molecule consists of two or more atoms joined by shared pairs of electrons in a chemical bond. It may consist of atoms of the same chemical element, as with oxygen (O2), or of different elements, as with water (H2O). Abstractly, a single atom may be considered a molecule, as it is when referred to collectively with molecules of multiple atoms, but in practice the use of the word molecule is usually confined to chemical compounds, of multiple atoms.
Isotopes are forms of a chemical element whose nuclei have the same atomic number, Z, but different atomic masses, A. The word isotope, meaning at the same place, comes from the fact that all isotopes of an element are located at the same place on the periodic table.
The atomic number corresponds to the number of protons in an atom. Thus, isotopes of a particular element contain the same number of protons. The difference in atomic masses results from differences in the number of neutrons in the atomic nuclei.
Collectively, the isotopes of the elements form the set of nuclides. A nuclide is a particular type of atomic nucleus, or more generally an agglomeration of protons and neutrons. Strictly speaking, it is more correct to say that an element such as fluorine consists of one stable nuclide rather than that it has one stable isotope.

2 Fluid Dynamics

Atmosphere consists of 78% Nitrogen, 21% Oxygen, 1% other gases
`Troposphere` is where temperature decreases with altitude (1.98^{o}C 1000ft) and where the weather takes place.
Lapse Rate ISA International Standard Atmosphere = Temperature decreases 1.98^{o}C per 1000ft
Temperature Unit conversion F = 9C/5+32 C = 5/9(F-32) K=C+273
`Temperature Variation in the Troposphere` is above the Equator -80^{o}C , above 45^{o}N/S -56^{o}C , above the poles -45^{o}C
At Sealevel the atmosphere pressure is normally 950 - 1050mb or hpa (1013 hpa is standard)hpa = hecto pascal. With increase in altitude atmospheric pressure drops e.g. at 30,000ft the pressure is 300.9 hpa = `Pressure Altitude` = the ISA pressure given for a certain altitude (also `density altitude`). In reality this varies with the ambient temperature. `Density` = $\frac{Mass}{Volume}$ in kilogram per cubic meter . `Factors affecting density` when considering a gas are
$Density = \frac{Pressure}{GasConstant \cdot Absolutetemperature}$

Reduced air density above 10,000 ft affects the human body and leads to hypoxia, lack of judgement to sleepiness or collapse according to altitude.
The greater the `humidity`, the lower the air — humidity decreases the total pressure
`Performance Ceilings` Info from www.EASA66.com
`Service Ceiling` is the altitude where the rate of climb of an aircraft falls below 100 ft per minute
`Absolute Ceiling` is the altitude where the rate of climb of an aircraft falls to zero

Gas Laws Boyle's Law = P_1 x V_1 = P_2 x V_2
V= Volume , P= Pressure

Charles' Law = $\frac{V_1}{K_1} = \frac{V_2}{K_2}$ V= Volume , K= Constant — Volume increases by 1/273 per every ^{o}C

Combined Boyle's and Charles' Law
Equation $\frac{P_1 \cdot V_1}{K_1} = \frac{P_2 \cdot V_2}{K_2}$

Speeds

Indicated Airspeed IAS = dynamic air pressure of air against a vehicle = $\frac{1}{2}\rho V^2$

Rectified Airspeed RAS is IAS corrected for instrument position errors

Equivalent Airspeed EAS = Rectified Air Speed corrected for compressibility (as subtracted quantity)

True Airspeed TAS = the Equivalent Air Speed corrected for Density

Calibrated Air Speed CAS for mean sea level compressibility corrected indicators also corrected for instrument and position errors

Mach Number is the ratio of TAS to the local speed of sound

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3 Thermodynamics

The Laws of Thermodynamics:

1^{st} Law: Conservation of energy. This is a fundamental principle of mechanics, and more generally of physics. In thermodynamics, it is used to give a precise definition of heat. It is stated as follows: The work exchanged in an adiabatic process depends only on the initial and the final state and not on the details of the process. or The net sum of exchange of heat and work of a system with the environment is a change of property. The amount of property change is determined only by the initial and final states and is independent on the path through which the process takes place. or The heat flowing into a system equals the increase in internal energy of the system plus the work done by the system. or Energy cannot be created or destroyed, only modified in form.

2^{nd} Law: A far reaching and powerful law, it is typically stated in one of two ways: It is impossible to obtain a process that, operating in cycle, produces no other effect than the subtraction of a positive amount of heat from a reservoir and the production of an equal amount of work. (Kelvin-Planck Statement) or It is impossible to obtain a process that, operating in cycle, produces no other effect than a positive heat flow from a colder body to a hotter one.

3^{rd} Law: This law explains why it is so hard to cool something to absolute zero: All processes cease as temperature approaches zero. As temperature goes to 0, the entropy of a system approaches a constant.

Temperature Unit conversion F = 9C/5+32 C = 5/9(F-32) K=C+273

There are three mechanisms by which thermal energy is transported.

Above formulas you must have proficient knowledge to convert in all ways, so practice, practice, practice....!
Formulas below are only for understanding!

1.Convection Heated air rises, cools, then falls. Air near a heater is replaced by cooler air, and the cycle repeats.

2.Conduction Formula of conduction is **H = kA (T2 - T1)/L** H = Heat Conduction in Joules per Second. k = thermal conductivity (depends on material), A = area in square meters, L = length in meters, T2 and T1 in ^{o}C Conduction depends on material, area , length and temperature difference.

Bad conducting material is called insulator.

3.Radiation **H = eσAT4** where e = emissivity (0-1) , σ = Stefan-Boltzmann constant (greek letter sigma) = 5.67 x 10-8 J/(s-m2-K4) , A = surface area of object , T = Kelvin temperature

Absorption and Emission of Radiation: Dark surfaces absorb heat and bright surfaces reflect heat.

The **first law of thermodynamics** is often called the Law of Conservation of Energy. Energy can be transferred from one system to another in many forms. Energy can not be created nor destroyed. **E=MC^2**

The **second law of thermodynamics** states that heat cannot be transferred from one body to a second body at higher temperature without producing some other effect and the entropy of a closed system increases with time. Temperature (T) and entropy (S) are parameters determining the direction in which an irreversible process can go. The temperature of a body or a system determines whether the flow is in or out.

Absolute Zero = 0 Kelvin = -273.15^o Celsius

4 Gyros

(See http://en.wikipedia.org/wiki/Gyroscope)

Rigidity and First Law of Gyrodynamics.

If a rotating body is so mounted as to be completely free to move about any axis through the centre of the mass, then its spin axis remains fixed in inertial space however much the frame may be displaced.

Precession: Force applied in the direction of the spin results in the torque acting perpendicular to the axis around which the torque was applied.

Real wander of a gyro is actual movement of the spin axis caused by engineering imperfections such as friction and unbalance.

Apparent wander of a gyro is the apparent movement of the spin axis away from the local vertical. The cause of this apparent movement is the rotation of the Earth combined with gyros rigidity.

Transport wander happens when a gyroscope is transported from one point on the Earth to another.

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5 Optics

See http://en.wikipedia.org/wiki/Optics
The field of **optics** usually describes the behavior of visible, infrared and ultraviolet light; however since light is an electromagnetic wave, analogous phenomena occur in X-rays, microwaves, radio waves, and other forms of electromagnetic radiation. Optics can thus be regarded as a sub-field of electromagnetism. Some optical phenomena depend on the quantum nature of light and as such some areas of optics are also related to quantum mechanics.
Reflection of light may be specular (that is, mirror-like) or diffuse (that is, not retaining the image, only the energy) depending on the nature of the interface. Whether the interfaces consists of dielectric-conductor or dielectric-dielectric, the phase of the reflected wave may or may not be inverted.
Refraction in geometric optics is the change in direction of a wave due to a change in velocity. It happens when waves travel from a medium with a given refractive index to a medium with another. At the boundary between the media the wave changes direction; its wavelength increases or decreases but frequency remains constant. For example, a light ray will refract as it passes through water or glass; understanding of this concept led to the invention of the refracting telescope.

Fibre Optics: Function of **Data-links** is to convert electrical input signal to an optical signal, to transmit the optical signal over the optical fibre and to convert the optical signal back to an electrical signal.
Parts used in a data-link are transmitter (LED or Laser Diode), optical fibre (including connector, cable, splice and connector) and receiver (PIN Diode or Avalanche Diode and signal conditioning circuit.
The `signal in the cable can be distorted`, weakened due to `absorption, dispersion and scattering` in the fibre optics waveguide. Noise (causes weakening of the signal) can disturb the quality of the electrical signal.

Cables are classified as **single and multi-mode** fibres. `Cable loss` is the decrease of light in respect of input (may be `caused by impurities in the fibre material`). Loss is measured in dB/km. Low-Loss optical fibres have less impurities and are made of a high-Siclica-Core. Multi-mode Cables have nowadays a loss (attenuation) of 0.5 dB/km at a wavelength of about 1300nm, whereas single-mode cables have loss of 0.25 dB/km at a wavelength of about 1500nm (year 2000).

`Single mode cables` have less loss and are `used for long-haul systems`.

Aircraft tend to use multi-mode system cables over short distance e.g in a LAN with multiple connections.

Advantages of using fibre optical systems: System Performance, Economical - low installation - and cost per channel. Size and weight and environmental advantages e.g temperature,corrosion, immune to noise EMI (do not need a common ground), less signal losses, less bit errors, more rugged and less restrictive in harsh environment ....

6 Sound

Try out on http://en.wikipedia.org/wiki/Sound
Sound is an alternation in pressure, particle displacement, or particle velocity propagated in an elastic material. or series of mechanical compressions and rarefactions or longitudinal waves that successively propagate through medium that are at least a little compressible (solid, liquid or gas but not vacuum). In sound waves parts of matter (molecules or groups of molecules) move in a direction of the spreading of the disturbance (as opposite to transversal waves). The cause of sound waves is called the source of waves, e.g. a violin string vibrating upon being bowed or plucked.
A sound wave is usually represented graphically by a wavy, horizontal line; the upper part of the wave (the crest) indicates a compression and the lower part (the trough) indicates a rarefaction .
A **standing wave**
http://en.wikipedia.org/wiki/Standing_waves) (see also known as a stationary wave, is a wave that remains in a constant position. This phenomenon can occur because the medium is moving in the opposite direction to the wave, or it can arise in a stationary medium as a result of interference between two waves traveling in opposite directions.
The **Doppler effect**
(see http://en.wikipedia.org/wiki/Doppler_effect)is the apparent change in frequency or wavelength of a wave that is perceived by an observer moving relative to the source of the waves. For waves, such as sound waves, that propagate in a wave medium, the velocity of the observer and the source are reckoned relative to the medium in which the waves are transmitted. The total Doppler effect may therefore result from both motion of the source and motion of the observer.

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7 Statics

In physics, a **force** acting on a body is that which causes the body to accelerate; that is, to change its velocity. The concept appeared first in Newton's second law of motion of classical mechanics, and is usually expressed by the equation:
F= m x a
where F is the force, measured in newtons, m is the mass, measured in kilograms, and a is the acceleration, measured in metres per second squared. Scientists have developed a more accurate concept, defining force as the

derivative of momentum. Force is not a fundamental quantity in physics, despite the tendency to introduce students to physics via this concept. More fundamental are momentum, energy and stress. Force is rarely measured directly and is often confused with related concepts such as tension and stress.

Types of forces: Engineers uses many types of force: Coulomb's force (between electrical charges), gravitational forces (between masses), magnetic force, friction, spring force, ...

However, scientists consider there to be only four fundamental forces of nature, with which every observed phenomenon can be explained: the strong nuclear force, the electromagnetic force, the weak nuclear force, and the gravitational force. The former three forces have been accurately modeled using quantum field theory, but a successful theory of quantum gravity has not been developed, although it is described accurately on large scales by general relativity.

The SI unit used to measure force is the newton (symbol N), which is equivalent to $kg \cdot m \cdot s^{-2}$

Forces are part of everyday life, with examples such as:

gravity: objects fall, even after being thrown upwards, objects slide and roll down

friction: floors and objects are not extremely slippery

spring force, objects resist tensile stress, compressive stress and/or shear stress, objects bounce back.

electromagnetic force: attraction of magnets movement

The concept of **torque** in physics, also called moment or couple, originated with the work of Archimedes on levers. Informally, torque can be thought of as "rotational force". The rotational analogues of force, mass and acceleration are torque, moment of inertia and angular acceleration. The force applied to a lever, multiplied by its distance from the lever's fulcrum, is the torque. For example, a force of three newtons applied two metres from the fulcrum exerts the same torque as one newton applied six metres from the fulcrum. This assumes the force is in a direction at right angles to the straight lever. More generally, one may define torque as the cross product:

$T = r \cdot F$

where r is the vector from the axis of rotation to the point on which the force is acting F is the vector of force.

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8 Kinetics

Motion: The **distance** between two points is the length of a straight line between them. In the case of two locations on Earth, usually the distance along the surface is meant: either "as the crow flies" (along a great circle) or by road, railroad, etc. Distance is sometimes expressed in terms of the time to cover it, for example walking or by car. Sometimes a distance thus indicated is ambiguous because the means of transport is neither mentioned nor obvious.

Speed (symbol: ν) is the rate of motion, or equivalently the rate of change of position, expressed as distance d moved per unit of time t.

Speed is a scalar quantity with dimensions Length/Time; the equivalent vector quantity to speed is known as velocity. Speed is measured in the same physical units of measurement as velocity, but does not contain the element of direction that velocity has. Speed is thus the magnitude component of velocity.

Units of speed include:

metre per second, (symbol m/s), the SI derived unit kilometres per hour, (symbol km/h) miles per hour, (symbol mph) knot (nautical miles per hour) Mach, where Mach 1 is the speed of sound; Mach n is n times as fast. Mach 1 = 343 m/s (=speed of sound under average circumstances) = 1234.8 km/h speed of light in vacuum (symbol c) is one of the natural units c = 299,792,458 m/s [other important conversions] 1 m/s = 3.6 km/h 1 mph = 1.609 km/h 1 knot = 1.852 km/h = 0.514 m/s Vehicles often have a speedometer to measure the speed. The rate of change of speed with respect to time is termed acceleration.

In physics, **acceleration** (symbol: α = lower case alpha) is defined as the rate of change (or time derivative) of velocity. It is thus a vector quantity with dimension length/time^2. In SI units, this is metre/second^2.

To accelerate an object is to change its velocity over a period of time. In this strict scientific sense, acceleration can have positive and negative valuesrespectively called acceleration and deceleration (or retardation) in common speechas well as change of direction. Acceleration is defined technically as `the rate of change of velocity of an object with respect to time`.

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9 Dynamics

Mechanics can be seen as the prime, and even as the original discipline of physics. It is a huge body of knowledge about the natural world. It also constitutes a central part of technology. That is, how to apply this knowledge for humanly defined purposes. Briefly stated, mechanics is concerned with the motion of physical bodies, and with the forces that cause these motions, as well as with forces which such bodies may, in turn, give rise to. Due to the wide scope of the subject, one may well find topics that would not fit easily into even this general characterization. Thus the term "body needs to stand for a wide assortment of objects, including particles, projectiles, spacecraft, stars, parts of machinery, parts of `solids`, parts of fluids (`gases` and `liquids`), etc.

Rigid body dynamics: Newtons laws are:
Newton's First Law : Law of Inertia: Every body's center of mass continues in its state of rest, or of uniform motion in a right [straight] line, unless it is compelled to change that state by forces impressed upon it. A body's center of mass remains at rest, or moves in a straight line (at a constant velocity, v), unless acted upon by a net outside force.
Newton's Second Law : Fundamental law of dynamics: Force is Mass x Acceleration. The rate of change in momentum is proportional to the net force acting on the object and takes place in the direction of the force. The acceleration of an object of constant mass is proportional to the resultant force acting upon it.
Newton's Third Law : Law of reciprocal actions: Whenever one body exerts force upon a second body, the second body exerts an equal and opposite force upon the first body. Momentum is conserved.
Fluid mechanics or **fluid dynamics** is the study of the macroscopic physical behaviour of fluids . Fluids are specifically liquids and gases though some other materials and systems can be described in a similar way. The solution of a fluid dynamic problem typically involves calculating for various properties of the fluid, such as velocity, pressure, density, and temperature, as functions of space and time. The discipline has a number of subdisciplines, including aerodynamics (the study of gases) and hydrodynamics (the study of liquids). Fluid mechanics has a wide range of applications. For example, it is used in calculating forces and moments on aircraft, the mass flow of petroleum through pipelines, and in prediction of weather patterns, and even in traffic engineering, where traffic is treated as a continuous flowing fluid. Fluid mechanics offers a mathematical structure that underlies these practical discipines which often also embrace empirical and semi-empirical laws, derived from flow measurement, to solve practical problems.
See http://en.wikipedia.org/wiki/Temperature
Formally, **temperature** is that property which governs the transfer of thermal energy, or heat, between one system and another. When two systems are at the same temperature, they are in thermal equilibrium and no heat transfer will occur. When a temperature difference does exist, heat will tend to move from the higher temperature system to the lower temperature system, until thermal equilibrium is established. This heat transfer may occur via conduction, convection or radiation (see heat for additional discussion of the various mechanisms of heat transfer).
Temperature is related to the amount of thermal energy or heat in a system. As more heat is added the temperature rises, similarly a decrease in temperature corresponds to a loss of heat from the system. On the microscopic scale this heat corresponds to the random motion of atoms and molecules in the system. Thus, an increase in temperature corresponds in an increase in the rate of movement of the atoms in the system.
Temperature is an intrinsic property of a system, meaning that it does not depend on the system size or the amount of material in the system. Other intrinsic properties include pressure and density. By contrast, mass and volume are extrinsic properties, and depend on the amount of material in the system.

Density is calculated by dividing the `how much` by the `how big`, and is expressed in grams per cubic centimeter (g/cm^3) or kilograms per meter cubic ($\mathbf{kg/m^3}$). To find the **Specific Gravity** of a solid or liquid, you must know its density in kilograms per meter cubic ($\mathbf{kg/m^3}$) or in grams per centimeter cubic (g/cm^3). Then, divide this density by the density of pure water in the same units. If you use kg/m^3, divide by 1000. If you use g/cm^3, divide by 1.

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10 SI (International System) Units

Sl (International System) Units :		
Physical Quantity	**Name of Unit**	**Symbol**
length	meter	m
mass	kilogram	kg
time	second	s
thermodynamic temperature	kelvin	K
electric current	ampere	A
luminous intensity	candela	cd
amount of substance	mole	mol
Derived Sl Units with special names:		
Physical Quantity	**Name of Unit**	**Symbol**
frequency	hertz	Hz
energy	joule	J
force	newton	N
power	watt	W
pressure	pascal	Pa
electric charge	coulomb	C
electric potential difference	volt	V
electric resistance	ohm	Ω
electric conductance	siemens	S
electric capacitance	farad	F
magnetic flux	weber	Wb
inductance	henry	H
magnetic flux density	tesla	T
luminous flux	lumen	lm
illuminance	lux	lx
Info from www.EASA-66.com		

Formulas you should be familiar with
Linear motion Distance x = $\nu \cdot t$ = distance · time
acceleration $\alpha = \frac{\nu}{t}$ = velocity / time
`linear acceleration:` distance x = $0.5 \cdot \nu \cdot t$
distance x = $0.5 \cdot \alpha \cdot t^2$ $\quad \nu = \alpha \cdot t$
x in m = metre , ν in $\frac{m}{s}$, α in $\frac{m}{s^2}$
F = force in N = newton , m = mass in kg
Force = m $\cdot \alpha$
Volume V in m^3 , m = mass in kg , Density ρ in $\frac{kg}{m^3}$
$\rho = \frac{m}{V}$
Weigh = Force = m · g , where g is acceleration due to gravity ($9.81 \frac{m}{s^2}$)
Torque = M for moment = F · d (Force · distance)

... to be continued ....

Decimal multiples and sub-multiples prefixes:					
Submultiple	**Prefix**	**Symbol**	**Multiple**	**Prefix**	**Symbol**
10^{-1}	deci	d	10	deca	da
10^{-2}	centi	c	10^{2}	hecto	h
10^{-3}	milli	m	10^{3}	kilo	k
10^{-6}	micro	μ	10^{6}	mega	M
10^{-9}	nano	n	10^{9}	giga	G
10^{-12}	pico	p	10^{12}	tera	T
10^{-15}	femto	P	10^{15}	peta	P
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