The basics of physics to the anesthesiologist.

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Application of Physics in Anesthesiology

 Basic knowledge of physics necessary for a full understanding of the functioning of many anesthetic apparatus.

main topics of the lectures

- pressure and flow of gases and liquids.
- electricity and electrical safety.

- Base SI units
- length (meter)
- mass (kilogram)
- time (second)
- current (ampere)
- temp (kelvin)
- luminous intensity (candela)
- amount of substance (mole)

- DERIVED UNITS
- temp in degrees celcius
- force (newton)
- pressure (pascal)
- - pressure (bar)
- energy (electron volt)
- power (watt)
- frequency (hertz)
- volume (liter)

- UNITS NOT IN THE SI SYSTEM
- pressure (mmHg)
- pressure (cmh2o)
- pressure (std atmosphere)
- energy (calorie)
- force (kilogram weight)

- - 1 kilopascal = 7.5mmHg.
- - 1 Bar = 750mmHg
- - 1 kilopascal = 10.2cmH2O
- 1 std atmosphere = 101.325kPa
- - 1 calorie = 4.18 J
- 1 kilogram weight = 9.81N
- Pounds / in2(PSI) -Atmospheric Pressure PATM=14.7 PSI)

BASIC DEFINITIONS

 Fundamental values in the physics of mass, length, and are time.

table of physical quantities

	Quantity	Definition	Formula	Units	Dimensions
Basic Mechanical	Length or Distance	fundamental	d	m (meter)	L (Length)
	Time	fundamental	t	s (second)	T (Time)
	Mass	fundamental	m	kg (kilogram)	M (Mass)
	Area	distance ²	$A = d^2$	m ²	L ²
	Volume	distance ³	$V = d^3$	m ³	L ³
	Density	mass / volume	d = m/V	ka/m ³	M/L ³
	Velocity	distance / time	v = d/t	m/s c (speed of light)	L/T
	Acceleration	velocity / time	a = v/t	m/s ²	L/T2
	Momentum	mass × velocity	p = m-v	kg-m/s	ML/T
	Force Weight	mass × acceleration mass × acceleration of gravity	F = m-a W = m-g	N (newton) = kg·m/s ²	ML/T ²
	Pressure or Stress	force / area	p = F/A	Pa (pascal) = $N/m^2 = kg/(m \cdot s^2)$	M/LT ²
	Energy or Work Kinetic Energy Potential Energy	force × distance mass × velocity ² / 2 mass × acceleration of gravity × height	$E = F \cdot d$ $KE = m \cdot v^2/2$ $PE = m \cdot q \cdot h$	J (joule) = N·m = kg·m ² /s ²	ML ² /T ²
	Power	energy / time	P = E/t	$W (watt) = 1/s = kg \cdot m^2/s^3$	ML ² /T ³
	Impulse	force × time	1 = F-t	N-s = kg-m/s	ML/T
	Action	energy × time momentum × distance	S = E-t S = p-d	J-s = kg·m ² /s h (quantum of action)	ML ² /T
_	Angle	fundamental	0	° (degree), rad (radian), rev 360° = 2π rad = 1 rev	dimensionless
8	Cycles	fundamental	n	cyc (cycles)	dimensionless
Br	Frequency	cycles / time	f = n/t	Hz (hertz) = cyc/s = 1/s	1/T
8	Angular Velocity	angle / time	$\omega = \theta/t$	rad/s = 1/s	1/T
2	Angular Acceleration	angular velocity / time	$\alpha = \omega/t$	$rad/s^2 = 1/s^2$	1/T2
S	Moment of Inertia	mass × radius ²	$1 = m \cdot r^2$	kg·m ²	ML ²
otatio	Angular Momentum	radius × momentum moment of inertia × angular velocity	$L = r \cdot p$ $L = 1 \cdot \omega$	J-s = kg-m ² /s h (quantum of angular momentum)	ML ² /T
ä	Torque or Moment	radius × force moment of inertia × angular acceleration	$\tau = r \cdot F$ $\tau = 1 \cdot \alpha$	N·m = kg-m ² /s ²	ML ² /T ²
10	Temperature	fundamental	т	°C (celsius), K (kelvin)	K (Temp.)
5	Heat	heat energy	Q	$J(joule) = kg \cdot m^2/s^2$	ML^2/T^2
€.	Entropy	heat / temperature	S = Q/T	J/K	ML^2/T^2K
	Electric Charge +/-	fundamental	q	C (coulomb) e (elementary charge)	C (Charge)
	Current	charge / time	i = q/t	A(amp) = C/s	C/T
Electromagnetic	Voltage or Potential	energy / charge	V = E/q	V (volt) = 3/C	ML ² /CT ²
	Resistance	voltage / current	R = V/i	Ω (ohm) = V/A	ML^2/C^2T
	Capacitance	charge / voltage	C = q/V	F (farad) = C/V	C^2T^2/ML^2
	Inductance	voltage / (current / time)	L = V/(i/t)	H (benry) = V-s/A	ML2/T2
	Electric Field	voltage / distance force / charge	E = V/d E = F/q	V/m = N/C	ML/CT ²
	Electric Flux	electric field × area	$\Phi_E = E \cdot A$	$V \cdot m = N \cdot m^2 / C$	ML ³ /CT ²
	Magnetic Field	force / (charge × velocity)	B = F/q·v	T (tesla) = Wb/m ² = N·s/(C-m)	M/CT
	Magnetic Flux	magnetic field × area	Φ _M = B-A	Wb (weber) = V-s = J-s/C	ML ² /CT

Note: Other conventions define different quantities to be fundamental.

Nase, energy, momentum, engular momentum, and charge are conserved, which means the total amount does not change in an isolated system.

basic mechanical

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	Volume	distance ³	$V = d^3$	m ³	L ³
	Density	mass / volume	d = m/V	kg/m ³	M/L ³
	Velocity	distance / time	$\mathbf{v} = \mathbf{d}/\mathbf{t}$	m/s c (speed of light)	L/T
	Acceleration	velocity/time	$\mathbf{a} = \mathbf{v}/\mathbf{t}$	m/s ²	L/T^2
	Momentum	mass × velocity	p = m · v	kg·m/s	ML/T
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Basic n	Pressure or Stress	force / area	p=F/A	$Pa (pascal) = N/m^2 = kg/(m \cdot s^2)$	<i>M/LT</i> ²

electricity

Ohms Law Formulas								
Known Values	Resistance (R)	Current (I)	Voltage (V)	Power (P)				
Current & Resistance			V = IxR	$P = I^2 x R$				
Voltage & Current	$R = \frac{V}{I}$			P = VxI				
Power & Current	$R = \frac{P}{I^2}$		$V = \frac{P}{I}$					
Voltage & Resistance		$I = \frac{V}{R}$		$P = \frac{V^2}{R}$				
Power & Resistance		$I = \sqrt{\frac{P}{R}}$	$V = \sqrt{PxR}$					
Voltage & Power	$R = \frac{V^2}{P}$	$I = \frac{P}{V}$						

FLUIDS

 Substances may exist in solid, liquid or gaseous form. In solids, molecules oscillate about a fixed point, whereas in liquids the molecules possess higher velocities and move more freely and thus do not bear a constant relationship in space to other molecules.

FLUIDS

 The molecules of gases also move freely, but to an even greater extent. Both gases and liquids are termed fluids. Liquids are incompressible and at constant temperature occupy a fixed volume, conforming to the shape of a container; gases have no fixed volume but expand to occupy the total space of a container.



• There are three important laws which determine the behaviour of gases and which are important to anaesthetists.

- Boyle's law states that, at constant temperature, the volume (V) of a given mass of gas varies inversely with its absolute pressure (P):
- P1*V1 = P2*V2

- *Charles' law* states that, at constant pressure, the volume of a given mass o f gas varies directly with its absolute temperature (*T*):
- V1/T1=V2/T2
- T_1 = Initial Temperature (*Kelvin K*)
- V_1 = Initial Volume (*L* or mL)
- T₂ = Final Temperature (*Kelvin K*)
- V_2 = Final Volume (*L or mL*)

 The third gas law indicates that at constant volume the absolute pressure on the gas varies directly with the absolute temperature or P / T = constant. Therefore at constant volume a doubling of temperature results in a doubling of pressure.

 Combining these three gas laws: P1*V1/T1=P2*V2/T2

- The behaviour of a mixture of gases in a container is described by *Dalton's law of partial pressures.*
- This states that, in a mixture of gases, the pressure exerted by each gas is the same as that which it would exert if it alone occupied the container.
- Thus, in a cylinder of compressed air at a pressure of 100 bar, the pressure exerted by nitrogen is equal to 79 bar (as the fractional concentration of nitrogen is 0.79).

Avogadro's hypothesis

 Avogadro's hypothesis states that equal volumes of gases at the same temperature and pressure contain equal numbers of molecules.

Avogadro's hypothesis

Critical temperature

Critical temperature

Pressure notation in anaesthesia

Pressure notation in anaesthesia