Technical content

Chapter 1 *Roller coasters*

Generic and transformable nature of energy; potential and kinetic energy; work and energy; Galileo's Law of gravity; conservation of energy; Newton's Laws; energy of body in a gravitational field; MKS units and the Système Internationale (SI); commutation (in multiplication); radian measure; energy conversion (transformation); rolling resistance; air resistance; resolution of vectors; mechanical equilibrium; sine/cosine/tangent; small angle approximation; Newton's Second Law in terms of momentum; 'δ' notation "for small change in"; circular motion; centripetal acceleration and force; 'g' as unit of acceleration; Newton's Law of Gravitation; planetary/geosynchronous orbit; effect of camber; physiological limits to acceleration; relativity of motion; negative energy; chemical and nuclear energy; constancy of velocity of light; mass as energy; conservation of mass/energy.

Chapter 2 *Planetary climate*

Energy *vs* power; electric, magnetic & electromagnetic (EM) fields; thermal energy; temperature as 'hotness'; hotness *vs* heat; absolute (Kelvin) temperature scale; thermal radiation; Stefan-Boltzmann Law; radiative equilibrium; reflection/absorption/emission of EM radiation; specular reflection; planetary albedo; absorption/emission by black body; solar power output, incidence on Earth; luminosity and inverse-square law; solar constant; solar energy capture; atomic & molecular absorption/emission of EM radiation; simple & compound greenhouse effect; optical depth; atmospheric thermal transport (evaporation/condensation); paleoclimatology; feedback, positive & negative; science *vs* religion.

Chapter 3 *Space*

Velocity required for low & geosynchronous Earth orbit (LEO, GEO); Earth equatorial velocity; sidereal day; escape velocity; Tsiolkovsky Rocket Equation; exhaust velocity of chemical & nuclear rocket; Δv as measure of propellent; payload ratio and step rocket; consequences of Rocket Equation for interplanetary return (must refuel at destination); tower, in compression & tension; specific strength/length.

Appendix: incommensurability & irrational numbers ; Euler's number e; differentiation, of polynomials and logarithms; integration & (first) fundamental theorem of calculus.

Chapter 4 *Computers*

Information and memory; logarithmic measure of information; signal vs noise; sampling & integration; quantization ('digitization'); digital *vs* analogue signal/record; register, state & value; register base (radix) *vs* cost; representation of (signed) number; synchronous *vs* asynchronous communication; synchronization; system compositionality/modularity; propositional calculus & Boolean algebra; logic gates; compositional logic; state machines (automata); fabrication of gates from switches; latch & flip-flop; register transfer; arithmetic logic with "look ahead" carry; machine instructions; fetch/execute cycle; conditional branch; stack and load/store architecture; assembly language; instruction execution pipeline; time/space diagram; memory requirements; memory hierarchy & caching; mean cost & delay; memory-mapped i/o; processor interruption; parallel computation; social impact of (unbounded) automation.

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