Physics – programme

1. INTRODUCTION / THE SCIENTIFIC METHOD
- What is Physics?
- Physics as experimental science
- Four fundamental types of interaction
- The language of Physics: concepts, laws, principles, models, theories
- Units
- Scalars and vectors
- THE SOLAR SYSTEM

2. ON SCALE
Length, surface and volume: surprising connections.

3. FORCE AND MOTION
- Kinematics as "geometry of Physics" – assumptions: coordinate systems (Cartesian, Polar, Spherical); material point, trajectory of motion;
- 1D kinematics (free fall)
- 2D kinematics (motion in gravitational field)
- Uniform and nonuniform circular motion
  ### LAWS OF DYNAMICS
- Assumptions of classical mechanics (small velocity, macroscopic objects)
- Classification of forces
- Inertial frame of reference: Newton's Laws of Dynamics (examples: single body diagrams in problems)
- Force of friction
- Deterministic nature of mechanics
  ### NONINERTIAL REFERENCE FRAMES
- Inertial reference frame: Galilean Relativity Principle
- Analysis of motion in noninertial reference frames: the idea of force of inertia (a few examples)
- Coriolis force

4. ENERGY AND WORK
- Work for a constant and varying force (a spring force, Hook's law)
- Work-energy theorem
- Conservative and nonconservative forces
- Conservation of mechanical energy
- Gravitational potential energy
- Newton's Law of Gravity
- Mechanical power
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5. MOMENTUM
- Conservation of momentum for a particle mass
- Conservation of momentum for a system of particles
- Collisions
- Impuls
- Center of mass

6. ROTATIONAL MOTION
- Kinematics of rotational motion
- Rotational kinetic energy (*a fly wheel, a spinning nuclear star*)
- Moment of inertia
- Angular momentum for a particle mass

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- Angular momentum for a rigid body
- Torque
- Conservation of angular momentum for a system of particles
- Conservation of angular momentum for a rigid body
        ROTATIONAL DYNAMICS
- Rotational dynamics of a rigid body about a fixed axis
- Rolling

7. OSCILLATORY MOTION
- Simple harmonic motion
- A simple pendulum
- A physical pendulum (examples, e.g. *Tyranosaurus Rex's leg*)
- Damped oscillations
- Forced oscillations and resonance

8. RELATIVITY
- Einstein postulates
- Relativity of simultaneity and time intervals
- Proper time
- The Twin Paradox
- Time dilation
- Length contraction
- Lorentz transformations
- Relativistic velocity transformations
        *RELATIVISTIC DYNAMICS
- Relativistic momentum and mass
- Relativistic work and energy
- Rest energy
- Mass and energy equivalence
- Nuclear energy and other sources of energy: discussion

9. MATTER AND ENERGY
- Basic quantities
- Avogadro's number: failure of classical mechanics
        TEMPERATURE AND HEAT
- Temperature: the 0th Law of Thermodynamics
- Ideal gas
- Thermal expansion: e.g. unusual behaviour of water
        ENERGY TRANSFORMATIONS
- Heat, internal energy, work (the concept of state function)
- Specific heat, heat capacity, molar heat capacity
- The first Law of Thermodynamics
- Applications of the 1st Law of Thermodynamics: various types of processes
- $C_p - C_v = R$: discussion
- The 2nd Law of Thermodynamics
- Reversible and irreversible processes
- Entropy
- Heat engines
- Carnot Cycle

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KINETIC THEORY OF MATTER
- Thermodynamics potentials (conditions of thermodynamic equilibrium for various conditions of thermodynamic systems)
- Statistical definition of entropy
- Maxwell-Boltzmann distribution

ELECTRICITY AND MAGNETISM

10. ELECTRIC FIELD
Properties of electric charge
Why a rubbed amber does attract bits of neutral paper?
Coulomb's Law
Electric field intensity and electric potential
Electric field potential energy
Electric field lines; equipotential surfaces;
Electric flux
Gauss's Law and its applications for symmetrical geometries
Conductor in an electric field (electrostatic case)
Applications of electrostatics (e.g. Van de Graaff generator, xerography)
Electrical conduction (metals, semiconductors, isolators, superconductors)
Classical model of electrical conduction in metals

11. MAGNETIC FIELD
Magnetic field properties
Lorentz force
A single charge in a magnetic field
A current-carrying conductor in a magnetic field (a steady current case)
Electric motor idea
Biot-Savart Law
Amper's Law
Gauss's Law for a magnetic field
Applications of a magnetic field (e.g. a magnetic bottle)
Faraday's Law

12. WAVES
Electromagnetic waves

13. LIGHT
Nature of light
Interference of Light (Young's experiment)
Blackbody radiation spectrum
The photoelectric effect
Compton effect

14. MODERN PHYSICS I
Radioactivity
Atomic models. The Bohr model
Nuclear energy
Fission and Fusion
*Elementary particles

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15. MODERN PHYSICS II
Wave-particle duality of light
De Broglie waves
Heisenberg uncertainty principle
Quantum numbers for the hydrogen atom
Nature of X-rays
Pauli exclusion principle