MARKHOR JUNIOR CONTEST

SCIENCE COURSE OUTLINE

ELEMENTARY LEVEL

(Applicable to Elementary V & Elementary VI)

Chapter No.	Chapter Title	Topic No.	Topic Title	Concept Description
01	Scientific Investigation and Engineering Design	1	**Identifying Problems and Testable Questions**	Turning observations into focused, investigable questions and deciding what evidence is needed to answer them.
		2	**Experimental Design and Variables**	Identifying independent, dependent and controlled variables, using control experiments, and choosing a suitable sample size and range.
		3	**Instruments, Accuracy and Precision**	Selecting instruments by resolution and range, and distinguishing accuracy (closeness to the true value) from precision (closeness of repeated readings).
		4	**Processing and Presenting Data**	Calculating means and ranges, drawing line graphs with lines of best fit, and using interpolation and extrapolation to read values.
		5	**Errors, Reliability and Evaluation**	Random and systematic errors, parallax and zero errors, handling anomalous results, and improving reliability through repeats.
		6	**Scientific Models**	Physical, diagrammatic and mathematical models (particle model, Solar System model) and the strengths and limitations of each.
		7	**The Engineering Design Process**	Defining a problem, setting criteria and constraints, designing, building a prototype, testing and improving a solution.
02	Cell Biology	1	**Cell Theory**	All living things are made of cells, the cell is the basic unit of life, and new cells come only from existing cells. Includes the role of the microscope in this discovery.
		2	**Cell Organelles and Their Functions**	Functions of the nucleus, cell membrane, cytoplasm, mitochondria, ribosomes, chloroplasts, cell wall and vacuole, and comparison of plant and animal cells.
		3	**Microscopy and Magnification**	Parts of a light microscope, preparing slides with stains, and calculating total magnification (eyepiece × objective).
		4	**Movement Into and Out of Cells**	Diffusion of particles, osmosis of water across a partially permeable membrane, and an introduction to active transport.
		5	**Cell Division and Growth**	Cells divide to allow growth and repair, producing identical new cells. An introduction to the cell cycle.

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		6	**Unicellular Organisms**	How single-celled organisms such as Amoeba, Paramecium, Euglena and yeast carry out all life processes within one cell.
03	**Classification of Living Organisms**	1	**Five-Kingdom Classification and Naming**	Monera, Protista, Fungi, Plantae and Animalia, the hierarchy from kingdom to species, the definition of a species, and binomial nomenclature.
		2	**Major Plant Groups**	Algae, mosses, ferns, conifers and flowering plants compared by vascular tissue and reproduction, and the differences between monocots and dicots.
		3	**Animal Phyla and Vertebrate Classes**	Distinguishing features of the major invertebrate phyla and the five vertebrate classes, used to classify unfamiliar animals.
		4	**Viruses, Bacteria and Fungi Compared**	Viruses (protein coat and genetic material, reproduce only inside host cells), bacteria (no nucleus, cell wall) and fungi (hyphae, spores) compared.
04	**Plant Physiology**	1	**Photosynthesis and Limiting Factors**	The word and symbol equation ($6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$), the iodine test for starch, and how light intensity, carbon dioxide and temperature limit the rate.
		2	**Leaf Structure and Adaptations**	Cuticle, epidermis, palisade and spongy mesophyll, stomata and guard cells, and how each adapts the leaf for photosynthesis and gas exchange.
		3	**Aerobic and Anaerobic Respiration**	Aerobic respiration (glucose + oxygen → carbon dioxide + water + energy) compared with anaerobic respiration in yeast (fermentation) and in muscles (lactic acid).
		4	**Transport and Transpiration**	Structure of xylem and phloem, the transpiration stream, and how temperature, humidity, wind and light affect transpiration rate.
		5	**Seed Development and Germination**	From fertilisation to seed and fruit development, seed dormancy, and investigating the conditions needed for germination.
		6	**Plant Hormones and Tropisms**	Auxin as a plant hormone and how its uneven distribution causes shoots to bend towards light and roots to grow with gravity.
05	**Human Nutrition and Digestion**	1	**Nutrients and Food Tests**	Roles of carbohydrates, proteins, fats, vitamins, minerals, fibre and water, and tests for starch (iodine), sugar (Benedict's), protein (biuret) and fat (ethanol emulsion).
		2	**Balanced Diet and Deficiency Diseases**	How energy needs vary with age and activity, and deficiencies of vitamins A, C and D, iron and iodine (night blindness, scurvy, rickets, anaemia, goitre).
		3	**Digestion, Enzymes and Absorption**	Digestive organs and the enzymes amylase, protease and lipase, effects of temperature and pH on enzymes, and absorption through villi.
06	**Human Circulation and Breathing**	1	**The Heart and Double Circulation**	Atria, ventricles and valves, the pulmonary and systemic circuits, and why the left ventricle wall is thicker.

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		2	**Blood Vessels and Blood Components**	How arteries, veins and capillaries are adapted to their roles, and the functions of red cells (haemoglobin), white cells, platelets and plasma.
		3	**Breathing Mechanism and Gas Exchange**	How the diaphragm and intercostal muscles change chest pressure, adaptations of the alveoli, and the composition of inhaled and exhaled air.
		4	**Effects of Exercise and Smoking**	Changes in heart and breathing rates during exercise, oxygen debt, and the damage caused by tar and carbon monoxide in tobacco smoke.
07	**Coordination, Excretion and Support**	1	**Neurons and the Nervous System**	The central and peripheral nervous systems, sensory, relay and motor neurons, and the pathway of a reflex arc.
		2	**The Endocrine System**	Hormones as chemical messengers carried in blood, such as insulin (blood glucose) and adrenaline (fight or flight), and how they compare with nerves.
		3	**Excretion and the Kidneys**	Kidneys filter blood to remove urea and control water balance. Introduction to the nephron and dialysis.
		4	**Skeleton, Joints and Movement**	Functions of the skeleton including blood cell production in bone marrow, synovial joints, and antagonistic muscle action.
		5	**Homeostasis**	Keeping internal conditions constant, including body temperature (sweating, shivering), water balance and blood glucose.
08	**Health, Immunity and Disease**	1	**Pathogens and Disease Transmission**	Bacteria, viruses, fungi and protists as pathogens, routes of transmission, and the difference between communicable and non-communicable diseases.
		2	**The Immune System and Medicines**	Phagocytes, lymphocytes and antibodies, natural and vaccine immunity, herd immunity, and how antibiotic misuse leads to resistant bacteria.
		3	**Non-Communicable Diseases and Lifestyle**	Heart disease and type 2 diabetes, and risk factors such as poor diet, inactivity and smoking.
09	**Reproduction, Heredity and Evolution**	1	**Sexual and Asexual Reproduction**	Gametes and fertilisation compared with binary fission, budding and spore formation, and the advantages of each method.
		2	**Animal Reproductive Strategies**	Internal and external fertilisation, egg-laying and live birth, and differences in parental care across animal groups.
		3	**DNA, Genes and Chromosomes**	Genetic information is stored as DNA in chromosomes in the nucleus. Genes control characteristics, and human body cells have 46 chromosomes.
		4	**Inheritance and Variation**	Dominant and recessive traits as shown in Mendel's pea plants, and continuous and discontinuous variation.

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		5	**Adaptation and Natural Selection**	Variation, competition and survival of better-adapted individuals, which pass on their characteristics, with examples such as the peppered moth.
10	**Measurement and Physical Quantities**	1	**Physical Quantities and SI Units**	Base units (m, kg, s, A, K), derived units (m/s, N, J, Pa), prefixes (milli, centi, kilo, mega) and an introduction to standard form.
		2	**Measuring Techniques**	Measuring length, mass, volume and time accurately, reading a meniscus, and avoiding parallax error.
		3	**Density Calculations and Applications**	Using $\rho = m/V$ in g/cm³ and kg/m³, density of irregular solids and liquids, and predicting floating and sinking.
11	**Forces and Motion**	1	**Speed and Distance–Time Graphs**	Calculating average speed, and interpreting the gradient of a distance–time graph as speed.
		2	**Velocity and Acceleration**	Velocity as speed in a given direction, acceleration as the rate of change of velocity, and an introduction to speed–time graphs.
		3	**Newton's Laws of Motion**	Inertia (first law), resultant force and acceleration ($F = ma$, second law), and action–reaction force pairs (third law).
		4	**Gravity, Mass and Weight**	Weight = mass × gravitational field strength ($W = mg$, $g \approx 10$ N/kg on Earth), different g values on other planets, and free fall.
		5	**Friction, Drag and Terminal Velocity**	How friction and drag oppose motion, and how balanced forces lead to terminal velocity, as shown by a skydiver.
		6	**Pressure in Solids, Liquids and Gases**	$P = F/A$ in pascals, liquid pressure increasing with depth, atmospheric pressure, and hydraulic systems.
		7	**Moments, Centre of Gravity and Stability**	Moment = force × perpendicular distance, the principle of moments, and how centre of gravity affects stability.
12	**Work, Energy and Power**	1	**Work Done**	Work is done when a force moves an object ($W = F \times d$), measured in joules.
		2	**Energy Stores and Transfers**	Kinetic, gravitational potential, elastic, chemical and thermal stores, transfers by forces, heating, electricity and radiation, and Sankey diagrams.
		3	**Conservation of Energy and Efficiency**	Energy is never created or destroyed. Efficiency = useful energy output ÷ total energy input × 100%, and ways to reduce wasted energy.
		4	**Power**	Power is the rate of doing work ($P = W/t$), measured in watts, used to compare machines and appliances.
		5	**Simple Machines and Mechanical Advantage**	Mechanical advantage = load ÷ effort for the three classes of lever, pulley systems, inclined planes, screws and gears.

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13	Thermal Physics	1	**Internal Energy and Temperature Scales**	Brownian motion as evidence for moving particles, Celsius and Kelvin scales, and absolute zero (−273 °C).
		2	**Applications of Heat Transfer**	Applying conduction, convection and radiation to vacuum flasks, home insulation, cooling fins and greenhouses.
		3	**Specific Heat and Latent Heat**	Different materials need different energy to warm up, and water's high value. Energy is absorbed or released during change of state without a temperature change, as shown on heating curves.
		4	**Thermal Expansion and Its Applications**	Expansion in solids, liquids and gases, bimetallic strips in thermostats, and designing for expansion in structures.
14	Light and Optics	1	**Plane Mirrors and Ray Diagrams**	Laws of reflection, and the virtual, upright, laterally inverted image formed as far behind a mirror as the object is in front.
		2	**Refraction and Total Internal Reflection**	Light bends towards the normal when entering a denser medium. The critical angle, total internal reflection and optical fibres.
		3	**Lenses and Image Formation**	Converging and diverging lenses, focal length, real and virtual images, and uses in magnifying glasses, cameras and correcting short and long sight.
		4	**Colour, Filters and the Spectrum**	Primary colours of light (red, green, blue), mixing light, filters, and why objects appear differently coloured under coloured light.
		5	**The Electromagnetic Spectrum**	Radio waves, microwaves, infrared, visible light, ultraviolet, X-rays and gamma rays in order of wavelength, with their uses and hazards.
15	Waves and Sound	1	**Wave Properties**	Transverse and longitudinal waves, wavelength, frequency, amplitude, and wave speed = frequency × wavelength.
		2	**Sound Waves and Oscilloscope Traces**	Sound as longitudinal waves of compressions and rarefactions, its speed in air (about 340 m/s), and how pitch and loudness appear on oscilloscope traces.
		3	**Echoes and Ultrasound**	Using echo timing to calculate distance, and applications in sonar, ultrasound scanning and animal echolocation.
16	Magnetism and Electromagnetism	1	**Magnetic Fields and Induced Magnetism**	Field patterns between poles, induced magnetism in iron, temporary and permanent magnets, and Earth's magnetic field.
		2	**Electromagnets and Their Applications**	Field around a current-carrying wire and coil, factors affecting strength, and uses in relays, electric bells and loudspeakers.
		3	**Motors and Generators**	A current-carrying wire in a magnetic field experiences a force (the basis of motors), and moving a magnet in a coil induces a current (the basis of generators).

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17	Electricity	1	**Electric Charge and Static Electricity**	Charging by friction through electron transfer, charging by induction, and uses and dangers of static electricity.
		2	**Current, Voltage and Resistance**	Current (amperes) as the flow of charge, voltage (volts) as the push, and resistance (ohms), with correct use of ammeters and voltmeters.
		3	**Ohm's Law and Factors Affecting Resistance**	V = IR calculations, and how wire length, thickness, material and temperature affect resistance.
		4	**Series and Parallel Circuit Rules**	How current, voltage and total resistance behave in series and parallel circuits, and analysing simple circuit problems.
		5	**Electrical Power and Energy Costs**	P = IV, energy in kilowatt-hours, and calculating the cost of using appliances.
		6	**Mains Electricity and Safety**	Alternating and direct current, live, neutral and earth wires, fuses and circuit breakers, and safe use of appliances.
18	Atomic Structure and the Periodic Table	1	**Atomic Structure and Subatomic Particles**	Protons (positive) and neutrons (neutral) in the nucleus with electrons (negative) around it, their relative masses and charges, and why atoms are neutral.
		2	**Atomic Number, Mass Number and Isotopes**	The atomic number identifies an element, the mass number counts protons and neutrons, and isotopes such as carbon-12 and carbon-14 differ in neutrons.
		3	**Electron Arrangement**	Electrons fill shells (2, 8, 8) for the first 20 elements, and outer electrons determine chemical behaviour.
		4	**The Periodic Table: Groups and Periods**	Elements arranged by atomic number, group number matching outer electrons, periods matching shells, and Mendeleev's contribution.
		5	**Metals, Non-Metals and Group Trends**	Physical and chemical properties of metals, non-metals and metalloids, the reactive alkali metals and the unreactive noble gases.
19	Pure Substances, Mixtures and Separation	1	**Pure Substances and Mixtures**	Elements and compounds as pure substances with fixed melting and boiling points, used as a test for purity.
		2	**Homogeneous and Heterogeneous Mixtures**	Uniform mixtures such as solutions and alloys compared with non-uniform mixtures such as suspensions, with an introduction to colloids.
		3	**Solubility and Solubility Curves**	Solubility in grams per 100 g of water, factors affecting it, and reading solubility curves to predict crystallisation.
		4	**Advanced Separation Techniques**	Simple and fractional distillation, paper chromatography and Rf values, and crystallisation, selecting the best method for a given mixture.
20	Chemical Bonding, Formulas and Equations	1	**How Atoms Combine**	Ionic bonding (electron transfer between metals and non-metals) and covalent bonding (electron sharing between non-metals) at an introductory level.

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		2	**Chemical Formulas and Naming**	Interpreting formulas such as H_2O, CO_2, NaCl, $CaCO_3$ and H_2SO_4, counting atoms, and naming compounds ending in -ide and -ate.
		3	**Word and Balanced Equations**	Writing word equations from reactants to products and balancing simple symbol equations with state symbols.
21	**Chemical Reactions**	1	**Types and Evidence of Chemical Reactions**	Combination, decomposition, displacement and combustion reactions, and observable evidence of each.
		2	**Conservation of Mass**	Total mass is conserved in closed systems. Apparent mass change in open systems occurs when gases escape or are absorbed.
		3	**Acids, Bases and the pH Scale**	Properties of acids and alkalis, strong and weak acids at an introductory level, pH values of common substances, and universal indicator colours.
		4	**Neutralisation and Its Applications**	Acid + base → salt + water, and uses in antacids, treating acidic soil with lime and treating industrial waste.
		5	**Reactions of Acids with Metals and Carbonates**	Metal + acid → salt + hydrogen (squeaky pop test), and carbonate + acid → salt + water + carbon dioxide (limewater test).
		6	**Oxidation, Rusting and Combustion**	Oxidation as gain of oxygen, rust prevention, complete and incomplete combustion (carbon monoxide danger), and fire safety and extinguishers.
		7	**The Reactivity Series of Metals**	Ordering metals from potassium to gold, predicting displacement reactions, and linking reactivity to how metals are extracted.
22	**Chemistry of Air, Water and Everyday Substances**	1	**Composition of Air and Gas Tests**	Nitrogen, oxygen, argon and carbon dioxide in air, and tests for oxygen (relights a glowing splint), carbon dioxide (limewater) and hydrogen (squeaky pop).
		2	**Water: Composition and Properties**	Water as H_2O, its role as a solvent, its maximum density at 4 °C, why ice floats, and hard and soft water.
		3	**Common Chemicals and Hazard Symbols**	Uses of sodium chloride, sodium bicarbonate, calcium carbonate, chlorine and ammonia, and the meaning of chemical hazard symbols.
23	**Geology and Earth's Changing Surface**	1	**Earth's Internal Structure**	The crust, mantle, liquid outer core and solid inner core, evidence from seismic waves, and how temperature increases with depth.
		2	**Plate Tectonics**	Wegener's continental drift, plates moved by mantle convection, and divergent, convergent and transform boundaries.
		3	**Earthquakes, Volcanoes and Mountain Building**	Why these occur at plate boundaries, measuring earthquake magnitude, and how the Himalayas formed from colliding plates.

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		4	**Minerals and Their Properties**	Identifying minerals by crystal shape, hardness (Mohs scale 1–10), lustre and streak, and the difference between minerals and rocks.
		5	**The Rock Cycle in Depth**	Processes and timescales linking igneous, sedimentary and metamorphic rocks, and identifying rocks by grain size and texture.
		6	**Soil Profiles and Conservation**	Soil horizons, soil composition and types, causes of soil erosion, and conservation methods such as contour ploughing and terracing.
24	**Atmosphere, Weather and Oceans**	1	**Layers of the Atmosphere**	Temperature changes through the atmospheric layers, the ozone layer's absorption of ultraviolet light, and ozone depletion by CFCs.
		2	**Atmospheric Pressure and Wind Systems**	High and low pressure systems, isobars, land and sea breezes, and the monsoon.
		3	**Weather Forecasting**	Barometers, hygrometers, anemometers, weather maps, weather fronts and satellite data used to predict weather.
		4	**Climate and Its Controls**	How latitude, altitude, ocean currents, prevailing winds and distance from the sea determine climate zones.
		5	**Oceans, Currents and Tides**	Warm and cold ocean currents and their effect on climate, and how the Moon's gravity causes tides.
		6	**Groundwater and Water Resources**	Aquifers, the water table, wells and springs, and the effects of over-extraction of groundwater.
25	**Astronomy and Space**	1	**Gravity and Orbits**	Gravity keeps planets and moons in orbit, and orbital period increases with distance from the Sun.
		2	**Solar System Bodies**	Comparative data on planets (size, temperature, moons), dwarf planets, asteroids, comets, meteors and meteorites.
		3	**The Sun–Earth–Moon System**	Using orbital geometry to explain seasons, phases, eclipses and tides, including why eclipses do not happen every month.
		4	**Life Cycle of Stars**	Nebula, main sequence, red giant or supergiant, white dwarf, supernova and neutron star or black hole, and how star colour indicates temperature.
		5	**Galaxies and the Universe**	The Milky Way as a spiral galaxy, billions of galaxies, light-year distances, and an introduction to the Big Bang theory.
		6	**Rockets and Satellite Technology**	Rocket propulsion as action and reaction, geostationary and polar orbits, and satellites for GPS, communication and remote sensing.

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26	**Ecology and Ecosystems**	1	**Ecosystem Structure**	Population, community, habitat, niche, ecosystem and biome as levels of ecological organisation.
		2	**Ecological Pyramids and Energy Flow**	Pyramids of numbers, biomass and energy, and why only about 10% of energy transfers between trophic levels.
		3	**Ecological Relationships**	Predation, competition, mutualism, commensalism and parasitism, and predator–prey population cycles.
		4	**The Carbon and Nitrogen Cycles**	Photosynthesis, respiration, combustion and decomposition in the carbon cycle, and the role of bacteria in the nitrogen cycle.
		5	**Ecosystem Stability**	How biodiversity increases resilience, the role of keystone species, and the threat of invasive species.
27	**Human Impact and Sustainability**	1	**Air, Water and Soil Pollution**	Acid rain from sulfur dioxide, eutrophication from fertilisers, bioaccumulation of pesticides, and plastic pollution.
		2	**Greenhouse Effect and Climate Change**	How greenhouse gases trap heat, evidence for global warming (temperature records, ice cores), and impacts on people and ecosystems.
		3	**Deforestation and Habitat Destruction**	Effects on the carbon cycle, soil, water cycle and biodiversity, and approaches to reforestation.
		4	**Water Conservation and Resource Management**	Sustainable water use, efficient irrigation such as drip systems, and rainwater harvesting.
		5	**Waste Management and the Circular Economy**	Landfill, incineration and recycling processes, and designing products to be reused and recycled.
		6	**Renewable Energy Solutions**	Solar, wind, hydroelectric, geothermal and tidal energy, and the advantages and limitations of each.
		7	**Wildlife Conservation**	Endangered species, protected areas, captive breeding and seed banks, and community-based conservation that helped the markhor recover.

CURRICULUM SUMMARY

- **Total Chapters:** 27
- **Total Topics:** 131
- **Biology and Life Science Coverage:** 36 topics (Chapters 02–09): cell theory and organelles, osmosis, classification, plant physiology, nutrition and enzymes, circulation, coordination and homeostasis, immunity, heredity and natural selection.
- **Physics Coverage:** 36 topics (Chapters 10–17): SI units and measurement, motion and Newton's laws, pressure, moments, work, energy and power, thermal physics, optics, waves, electromagnetism and electricity.
- **Chemistry Coverage:** 22 topics (Chapters 18–22): atomic structure, isotopes, electron arrangement, the Periodic Table, mixtures and separation, bonding, formulas and equations, acids and bases, the reactivity series and gas tests.
- **Earth and Space Science Coverage:** 18 topics (Chapters 23–25): plate tectonics, minerals, the rock cycle, soil, atmosphere, weather forecasting, ocean currents, groundwater, orbits, stellar life cycles, galaxies and satellites.
- **Environmental Science Coverage:** 12 topics (Chapters 26–27): ecosystem structure, ecological pyramids, ecological relationships, carbon and nitrogen cycles, pollution, climate change, resource management, renewable energy and conservation.
- **Scientific Investigation and STEM Coverage:** 7 topics (Chapter 01): testable questions, experimental design, accuracy and precision, data processing, error analysis, scientific models and the engineering design process.
- **Overall Academic Focus:** The outline emphasises structures, mechanisms and quantitative reasoning: students explain processes in detail, use simple formulas, interpret data and apply principles to unfamiliar problems.

ACADEMIC PROGRESSION

Learner Level introduced scientific systems: cell parts, photosynthesis, the particle model, basic circuits, atoms and elements, and food chains. Elementary Level explains the mechanisms behind them and adds quantitative work: organelles and osmosis, limiting factors and respiration, Newton's laws and pressure calculations, Ohm's law, atomic structure and the Periodic Table, balanced equations, plate tectonics and nutrient cycles. Investigation also advances to controlled experimental design, error analysis and engineering design. This prepares students for Pioneer Level, where biology, chemistry and physics are studied as more distinct disciplines with greater mathematical and analytical depth.