BPHO Syllabus Round 2

General

a) The paper may contain, but is not limited to, the following topics. The material is at the level of ***Upgrade Your Physics*** found on https://www.bpho.org.uk/Resources/upgrade-your-physics/

b) ***Fundamentals of Physics***, by Halliday, Resnick & Walker is an excellent American University textbook which has the material well explained, hundreds of problems, is profusely illustrated with diagrams and is available in print relatively cheaply for good copies of older editions, or online for, again, an older but excellent (10^{th}) edition, at Halliday_Resnick_Walker_Fundamentals_of_Physics_10ed_extended_2014.pdf

c) The *extensive* use of the calculus (differentiation and integration) will not be required, nor the use of complex numbers or solving novel differential equations, in order to solve the theoretical and practical problems. However, the recognition that, for example, $N = N_0 e^{-\lambda t}$ is a solution to the differential equation $\frac{\mathrm{d}N}{\mathrm{d}t} = -\lambda N$, and that they can easily be related will be expected. The ability to set up a simple integral in a physics question may be required, but solutions to standard integrals will generally be given where needed.

d) Any A level/IB or equivalent formula sheet can be used. Less well known formulae will be given.

e) Questions may contain concepts and phenomena not contained in the Syllabus, but sufficient information will be given in the question so that candidates without previous knowledge of these topics would be able to progress.

The first column contains the main entries while the second column contains comments and remarks if necessary**.**

1. Mechanics

a) kinematics of a point mass	Vector description of the position of the mass; displacement, velocity and acceleration as vectors. Motion in 2-D in a uniform gravitational field.
b) Newton's Laws	
c) Momentum, energy, work, power	
d) Conservation of energy, conservation of linear momentum, impulse	
e) Elastic forces, frictional forces	Hooke's law, coefficient of friction ($\mu = F/R$), frictional forces, static and kinetic (μ_s, μ_e) .
f) Newton's Law of Gravitation	Potential, potential energy and work in a constant gravitational field. Choice of zero of potential energy
g) Centripetal acceleration.	

2. Mechanics of Rigid Bodies

a) Statics, center of mass, torque	Couples, conditions of equilibrium of bodies
b) Motion of rigid bodies	For rigid systems containing small numbers of point masses in translation and rotation. Angular velocity, constant angular acceleration and the equations of motion in their rotational equivalent form, but not in vector notation
c) Conservation of angular momentum	Conservation of angular momentum about a fixed axis only

3. Hydromechanics

NO specific questions will be set on this, but students will be expected to know the elementary concepts of Archimedes upthrust/buoyancy and the continuity law applied to conserved quantities.

4. Thermodynamics and Molecular Physics

a) Internal energy, work and heat, first law of thermodynamics	Thermal equilibrium, quantities depending on state and quantities depending on process
b) Absolute temperature	$< ke > \propto T$
c) Model of a perfect gas, pressure and molecular kinetic energy.	Also molecular approach to such simple phenomena in liquids and solids as boiling
d) Avogadro number	The mole
e) Equation of state of a perfect gas	$pV = nRT$
f) Work done	in isothermal changes
g) (Molar) specific heats of an ideal gas	C_P and C_V and Mayer's equation, $C_\mathrm{p} - C_\mathrm{V} = R$
h) Boltzmann factor	$E_2 = E_1 \exp\left(-\frac{(E_2 - E_1)}{kT}\right)$
i) Melting, boiling	Qualitative only

5. Oscillations and Waves

a) Harmonic oscillations, equation of harmonic oscillation	
b) Superposition of harmonic waves, coherent waves, interference, beats, standing waves	Fourier analysis is not required but candidates should have some understanding that complex waves can be made from the addition of simple sinusoidal waves of different frequencies. Superposition of waves from secondary sources (diffraction and interference)
c) Harmonic waves, propagation of waves, transverse and longitudinal waves	Attenuation and resonance – qualitatively That intensity of a wave is proportional to the square of its amplitude
a) Linear polarisation, the classical Doppler effect	In one dimension only
b) Solutions of the equation for harmonic motion	

c)	Displacement and phase in progressive and stationary waves	Understanding of graphical representation of these waves
d)	Measurements of velocity of sound and light	
e)	Propagation of waves in homogeneous and isotropic media, reflection and refraction	
f)	Realisation that intensity of wave is proportional to the square of its amplitude	
g)	Interference due to thin films and other simple systems	(final formulae are not required). Phase changes at reflecting surfaces.
h)	Fermat's principle	Applied to refraction

6. Electric Charge and Electric Current

a)	Conservation of charge, Coulomb's law for point charges	
b)	Current, resistance, internal resistance of sources, Ohm's law	
c)	Kirchhoff's laws	Simple cases of circuits containing non-ohmic devices with known V-I characteristics
d)	Alternating current	
e)	Work and power of direct and alternating current	Joule's law heating
f)	Electric field, potential, potential gradient	Electric fields of simple symmetric systems like sphere, cylinder, plate etc. and their potentials.
g)	Capacitors, capacitance, dielectric constant	Dielectric filling the space between the plates time constants
h)	Electric dipole moment	For two point charges, Q separated by a distance a, $p = Qa$
i)	Current and Magnetic Field (B) from a current	Magnetic field of simple symmetric systems like straight wire, circular loop and long solenoid
j)	Magnetic field (B) of a current, current in Particles in a magnetic field	Magnetic field, Lorentz force, applications like the cyclotron.
k)	Magnetic moment	For a current loop, $\mu = IA$
l)	Laws of electromagnetic induction, magnetic flux, Lenz's law, self-induction, inductance	
m)	Resistors, inductors, capacitors individually in simple AC-circuits	Resonance circuits are not required

7. Quantum Physics

a)	Photoelectric effect	Einstein's formula $E = hf - W$
b)	energy and momentum of the photon	$p = E/c$
c)	de Broglie (matter) waves	
d)	Uncertainty Principle	

8. Relativity

a)	Relativistic equation of motion	Momentum, energy, relation between energy and mass Not 4-vectors and not Lorentz transformations
b)	Conservation of energy and momentum	

9. Electromagnetic Waves

a)	Wave optics	Dispersion
b)	Diffraction from one and two slits, diffraction grating	Diffraction spectra, line spectra of gases
c)	Electromagnetic waves as transverse	
d)	Polarisation by reflection, polarisers	Superposition of polarised waves

10. Matter

a)	Energy levels of atoms and molecules	
b)	Emission, absorption, spectrum of hydrogen line	
c)	Energy levels of nuclei	
d)	Alpha, beta and gamma decays	Emission, absorption of radiation, half-life, exponential decay
e)	Components of nuclei, mass defect, nuclear reactions	

Refer to *Upgrading Your Physics* for guidance on the level at which this material is required.

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