STPM/S(E)960

PEPERIKSAAN
SIJIL TINGGI PERSEKOLAHAN MALAYSIA
(MALAYSIA HIGHER SCHOOL CERTIFICATE)

PHYSICS
Syllabus

Second Edition

This syllabus applies for the 1999 examination and thereafter until further notice. However the form of examination for Physics stated in this booklet was first implemented in the 2001 examination as announced through a circular, Pemberitahuan MPM/2(AM)/2000. Teachers/candidates are to advised to contact Majlis Peperiksaan Malaysia for the latest information about the syllabus.

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FALSAFAH PENDIDIKAN KEBANGSAAN

Pendidikan di Malaysia ialah suatu usaha yang berterusan ke arah memperkembang potensi individu secara menyeluruh dan bersepadu untuk melahirkan insan yang seimbang dan harmonis dari segi intelek, rohani, emosi, dan jasmani berdasarkan kepercayaan dan kepatuhan kepada Tuhan. Usaha ini bertujuan untuk melahirkan warganegara Malaysia yang berilmu pengetahuan, berketrampilan, berakhlak mulia, bertanggungjawab, dan berkeupayaan mencapai kesejahteraan diri serta memberikan sumbangan terhadap keharmonian dan kemakmuran keluarga, masyarakat, dan negara.

CONTENTS

960 PHYSICS

Aims

This syllabus aims to enhance students' knowledge and understanding of physics to enable them to further their studies at institutions of higher learning or to assist them to embark on a related career and also to promote an awareness among them of the role of physics in the universe.

Objectives

The objectives of this syllabus are to enable students to

(*a*) know, understand, and use models, law, principles, concepts, and theories of physics;

(*b*) understand, interpret, and use scientific information presented in various forms;

(*c*) solve problems in various situations;

(*d*) analyse, synthesise, evaluate, and deal with information and ideas logically and critically;

(*e*) plan and carry out experiments scientifically and make deductions;

(*f*) know techniques of operation and safety aspects of scientific equipment;

(*g*) develop proper attitudes and values in the study and practice of science.

Elementary Knowledge

Candidates will be assumed to have a good grounding of basic concepts of physics from the study of science up to SPM level or its equivalent.

Candidates will also be assumed to have acquired mathematical skills up to SPM Additional Mathematics or its equivalent.

Content

A. MECHANICS

1. Physical quantities and units (*3 double periods*)

1.1 Basic quantities and SI units

1.2 Dimensions of physical quantities

1.3 Scalars and vectors

1.4 Errors

Explanatory notes

Candidates should be able to

(*a*) list basic quantities like mass (kg), length (m), time (s), current (A), temperature (K), and quantity of matter (mol), and write their SI units

(*b*) show awareness of the existence and importance of international and national standard of measurements

(*c*) deduce units for derived quantities if the definitions are given

(*d*) list dimensions of basic quantities and determine dimensions of derived quantities (*e*) check and construct equations by using dimension analysis

(*f*) define scalar and vector quantities and quote examples

(*g*) know the operations for the sum of vectors (examples on coplanar vectors)

(*h*) resolve a vector to two perpendicular components

(*i*) show awareness that every measurement has errors

(*j*) know the differences between systematic errors and random errors

(*k*) write derived data to an appropriate number of significant figures

2. Kinematics and dynamics (*9 double periods*)

2.1 Rectilinear motion

2.2 Motion with constant acceleration

2.3 Projection

2.4 Newton's laws of motion

2.5 Conservation of momentum

2.6 Elastic and non-elastic collisions

Explanatory notes

Candidates should be able to

(*a*) define displacement, speed, velocity, and acceleration

(*b*) derive and use equations of motion with constant acceleration

(*c*) sketch and use the graphs of displacement-time, velocity-time, and acceleration-time for the motion of a body

(*d*) solve problems on projection without air resistance

(*e*) understand qualitatively the effects of air resistance on the motion of bodies in air

(*f*) state Newton's law of motion

(*g*) understand that a body has inertia

(*h*) use the formula $F = m\frac{\mathrm{d}(v)}{\mathrm{d}t}$ or $v\frac{\mathrm{d}(m)}{\mathrm{d}t}$

(*i*) state the principle of conservation of momentum and show the conservation of momentum by means of Newton's law of motion

(*j*) define impulse as $\int F\,\mathrm{d}t$ and show awareness that impulse is equivalent to the change of momentum

(*k*) distinguish between elastic collisions and non-elastic collisions

(*l*) solve problems regarding linear collisions between particles

3. Work, energy, and power (*3 double periods*)

3.1 Work

3.2 Potential energy

3.3 Kinetic energy

3.4 Conservation of energy

3.5 Power

3.6 Efficiency

Explanatory notes

Candidates should be able to

(*a*) define work done by a force, $\mathrm{d}W = \vec{F}.\mathrm{d}\vec{s}$

(*b*) calculate work from a graph of force versus displacement

(*c*) calculate work done in certain situations, including work done by a gas which is expanding against a constant external pressure

(*d*) use the formula: kinetic energy $= \frac{1}{2}mv^2$

(*e*) derive and use the formula: potential energy change $= mgh$, near the Earth's surface

(*f*) solve questions regarding the interchange between kinetic energy and potential energy

(*g*) use the principle of conservation of energy in situations involving change in forms of energy

(*h*) define power

(*i*) derive and use the formula $P = Fv$

(*j*) understand the concept of efficiency of systems and the consequences of heat dissipation

4. Circular motion (*4 double periods*)

4.1 Uniform circular motion

4.2 Centripetal acceleration

4.3 Centripetal force

Explanatory notes

Candidates should be able to

(*a*) describe circular motion using the terms of angular displacement, speed, angular velocity, and period

(*b*) understand that uniform circular motion has an acceleration that is caused by the change in direction of velocity

(*c*) understand that uniform circular motion is due to the action of a resultant force that is always directed to the centre of the circle

(*d*) use the formulae $v = r\omega,\ \omega = \frac{2\pi}{T}$

(*e*) derive and use the formulae $a = \frac{v^2}{r},\ a = r\omega^2$

(*f*) analyse examples of circular motion

5. Rotation of rigid body (*5 double periods*)

5.1 Kinematics of rotation

5.2 Centre of mass

5.3 Moment of inertia

5.4 Angular momentum

5.5 Conservation of angular momentum

5.6 Rotation kinetic energy

Explanatory notes

Candidates should be able to

(*a*) understand the concept of angular acceleration

(*b*) use equations of kinematics of rotation with uniform angular acceleration

(*c*) define the centre of mass and determine the centre of mass for a system of coplanar particles

(*d*) understand the situation where a rigid body can show translational motion, rotational motion, or translational motion with rotation

(*e*) explain the physical significance of moment of inertia and give its definition (*Geometrical derivations of moments of inertia are not required*.)

(*f*) define torque, $\vec{\tau} = \vec{r} \times \vec{F}$, and use the formula $\tau = I\dfrac{\mathrm{d}\omega}{\mathrm{d}t}$

(*g*) derive an expression for rotational kinetic energy of a rigid body

(*h*) define angular momentum and use the formula $L = I\omega$

(*i*) use the principle of conservation of angular momentum

(*j*) understand the motion of a sphere/cylinder which is rolling down an inclined plane

6. Statics (*3 double periods*)

6.1 Equilibrium of particles

6.2 Closed polygon

6.3 Equilibrium of rigid bodies

6.4 Frictional forces

Explanatory notes

Candidates should be able to

(*a*) state the conditions for equilibrium of particles

(*b*) sketch and label the forces which act on a body by means of a vector diagram

(*c*) sketch the triangle of forces or the polygon of forces to represent forces in equilibrium

(*d*) understand a couple as a pair of forces tending to rotation only

(*e*) state the conditions for equilibrium of a rigid body (*f*) understand that the action of frictional forces maintains a body in equilibrium

(*g*) understand that the frictional force is a force which has a maximum value of μR

7. Gravitation (*3 double periods*)

7.1 Newton's law of universal gravitation

7.2 Gravitational field strength

7.3 Gravitational potential

7.4 Relationship between *g* and *G*

7.5 Satellite motion in circular orbits

7.6 Escape velocity

Explanatory notes

Candidates should be able to

(*a*) state and use Newton's law of universal gravitation, $F = \frac{GMm}{r^2}$

(*b*) define gravitational field strength as force of gravity per unit mass

(*c*) derive and use the equation $g = \frac{GM}{r^2}$ for a gravitational field

(*d*) define the potential at a point in a gravitation field

(*e*) derive and use the formula $V = -\frac{GM}{r}$

(*f*) use the formula for potential energy, $U = -\frac{GMm}{r}$

(*g*) understand that $U = mgh$ is a special case for $U = -\frac{GMm}{r}$ for situations near the Earths' surface

(*h*) use the relationship $g = -\frac{\mathrm{d}V}{\mathrm{d}r}$

(*i*) explain graphically the variations of gravitational field strength and potential gravitational with distance from the Earth

(*j*) solve problems regarding the motion of a body in circular orbit in a gravitational field

(*k*) understand the concept of weightlessness

(*l*) derive and use the equation $v_e = \sqrt{2gr}$ for escape velocity

8. Simple harmonic motion (*3 double periods*)

8.1 Characteristics of simple harmonic motion

8.2 Kinematics of simple harmonic motion

8.3 Energy in simple harmonic motion

8.4 Systems in simple harmonic motion

Explanatory notes

Candidates should be able to

(*a*) define simple harmonic motion by means of the equation $a = -\omega^2 x$

(*b*) understand the equation $x = x_0 \sin \omega t$ as a solution of $a = -\omega^2 x$

(*c*) derive and use equation for velocity in the terms of *x*

(*d*) derive and use the expressions for kinetic energy and potential energy

(*e*) describe graphically the variation in displacement, velocity, acceleration, kinetic energy, potential energy

(*f*) derive and use expressions for period of oscillation for linear motion such as spring-mass and angular motion such as simple pendulum

(*g*) analyse examples of simple harmonic motion

9. Oscillations (*1 double period*)

9.1 Free oscillations

9.2 Damped oscillations

9.3 Forced oscillations

9.4 Resonance and damping

Explanatory notes

Candidates should be able to

(*a*) describe the changes in amplitude and energy for a damped oscillating system

(*b*) distinguish between under damping, critical damping, and over damping

(*c*) distinguish between free oscillations and forced oscillations

(*d*) describe graphically the variation in amplitude of forced vibrations with forced frequencies

(*e*) state the conditions for resonance to occur

B. WAVES

10. Wave motion (*3 double periods*)

10.1 Waves and energy

10.2 Progressive waves

10.3 Wave intensity

10.4 Principle of superposition

10.5 Standing waves

10.6 Longitudinal waves and transverse waves

Explanatory notes

Candidates should be able to

(*a*) explain how waves are formed and give examples of waves

(*b*) understand the relationship between waves and energy

(*c*) define displacement, amplitude, frequency, period, wavelength, and wavefront

(*d*) interpret and use the progressive wave equation, $y = a \sin(\omega t - kx)$ or $y = a \cos(\omega t - kx)$

(*e*) sketch and interpret the displacement-time graph and the displacement-distance graph

(*f*) use the formula $\phi = \frac{2\pi x}{\lambda}$

(*g*) derive and use the relationship $v = f\lambda$

(*h*) define intensity and use the relationship $I \propto a^2$

(*i*) use the variation of intensity with distance of a point source

(*j*) explain the principle of superposition

(*k*) use the principle of superposition to explain the formation of standing waves

(*l*) derive and interpret the standing wave equation

(*m*) distinguish between progressive waves and standing waves

(*n*) understand the properties of longitudinal waves and transverse waves and give examples of these waves

11. Sound waves (*4 double periods*)

11.1 Propagation of sound waves

11.2 Sources of sound

11.3 Intensity of sound

11.4 Beat

11.5 Doppler effect

Explanatory notes

Candidates should be able to

(*a*) understand sound as a form of longitudinal wave

(*b*) understand the propagation of sound waves in terms of pressure variation and displacement

(*c*) interpret the equations for displacement, $y = y_0 \sin(\omega t - kx)$, and pressure, $p = p_0 \sin\left(\omega t - kx + \frac{\pi}{2}\right)$

(*d*) describe quantitatively the formation of standing waves along stretched strings and use the formula for the frequency of the sound waves produced

(*e*) describe quantitatively the formation of standing waves in air columns and use the formula for frequency including the determination of end correction

(*f*) understand quantitatively the production of sound waves by vibrating membranes

(*g*) use dB to define the levels of intensity

(*h*) use the principle of superposition to explain the formation of beats

(*i*) use the formula for beat frequency, $f = f_1 - f_2$

(*j*) describe quantitatively the Doppler effect for sound and use the derived formulae

C. PROPERTIES OF MATTER

12. State of matter (*2 double periods*)

12.1 Solid, liquid, and gas

12.2 Crystalline solids

12.3 Intermolecular force curve

12.4 Potential energy curve

Explanatory notes

Candidates should be able to

(*a*) distinguish between solids, liquids, and gases based on the arrangement of atoms and with the use of simple kinetic theory model

(*b*) explain the properties of crystalline solids with reference to examples

(*c*) interpret and use the *F*–*r* graph

(*d*) understand the relationship between Hooke's law and the *F*–*r* graph

(*e*) interpret and use the *U*–*r* graph

(*f*) use the *U*–*r* graph to explain the expansion of solids when heated

13. Deformation of solids (*3 double periods*)

13.1 Stress and strain

13.2 Force-extension graphs and stress-strain graphs

13.3 Young modulus

13.4 Strain energy

Explanatory notes

Candidates should be able to

(*a*) define stress and strain for a stretched wire or elastic string

(*b*) sketch and interpret force-extension graphs and stress-strain graphs

(*c*) distinguish between elastic deformation and plastic deformation (*d*) distinguish the shapes of force-extension graphs for ductile, brittle, and polymeric materials

(*e*) define the Young modulus

(*f*) describe an experiment to determine the Young modulus of a metal in the form of a wire

(*g*) derive and use the formula for strain energy

(*h*) calculate strain energy from force-extension graphs or stress-strain graphs

D. THERMODYNAMICS

14. Kinetic theory of gases (*4 double periods*)

14.1 Ideal gas equation

14.2 Kinetic theory of gases

14.3 Pressure of a gas

14.4 Molecular kinetic energy

14.5 R.m.s. speed of molecules

14.6 Degrees of freedom

14.7 Law of equipartition of energy

14.8 Internal energy of an ideal gas

14.9 Distribution of molecular speeds

Explanatory notes

Candidates should be able to

(*a*) understand the concept of Avogadro number

(*b*) use the equation of ideal gas, $pV = nRT$

(*c*) know the relationship between Boltzmann constant and gas constant

(*d*) use assumptions of the kinetic theory of gases to derive the equation for pressure exerted by an ideal gas, $p = \frac{1}{3}\rho < c^2 >$ or $p = \frac{1}{3} nm < c^2 >$

(*e*) derive expressions for translational kinetic energy

(*f*) show that molecular kinetic energy is directly proportional to the thermodynamic temperature of the gas

(*g*) derive and use the formula for r.m.s. speed $\sqrt{< c^2 >} = \sqrt{\frac{3kT}{m}}$ for gas molecules

(*h*) define the degree of freedom

(*i*) identify the number of degrees of freedom for molecules of a monoatomic, diatomic, and polyatomic gas

(*j*) explain the variation in the number of degrees of freedom for molecules of a diatomic gas ranging from very low temperatures to very high temperatures

(*k*) explain the law of equipartition of energy

(*l*) distinguish between an ideal gas and a real gas (*m*) understand the concept of internal energy of an ideal gas

(*n*) know the relationship between internal energy and a single degree of freedom

(*o*) sketch graphs to show the distribution of speeds of molecules and explain the shape of the graph (*Description of the experiment is not required.*)

(*p*) predict the variation of molecular speed distribution with temperature

15. Thermodynamics of gases (*5 double periods*)

15.1 Heat capacity

15.2 Work

15.3 First law of thermodynamics

15.4 Internal energy

15.5 Isothermal change

15.6 Adiabatic change

Explanatory notes

Candidates should be able to

(*a*) define heat capacity, specific heat capacity, and molar heat capacity

(*b*) use the equations $Q = C\Delta\theta$, $Q = mc\Delta\theta$, $Q = nC_{\text{V,m}}\Delta\theta$,

(*c*) understand that c_{p} and c_{V} depend on the degrees of freedom

(*d*) derive and use the equation for work done by gas during expansion, $W = \int p\,\text{d}V$

(*e*) understand and use the first law of thermodynamics, $Q = \Delta U + \Delta W$

(*f*) understand the concept of internal energy from the first law of thermodynamics

(*g*) derive and use the equation $C_{\text{p,m}} - C_{\text{V,m}} = R$

(*h*) know that $\gamma = c_{\text{p}}/c_{\text{V}}$

(*i*) understand the isothermal process of a gas

(*j*) use the equation $pV =$ constant for isothermal changes

(*k*) understand the adiabatic process of a gas

(*l*) use the equations $pV^{\gamma} =$ constant and $TV^{\gamma-1} =$ constant for adiabatic changes

(*m*) illustrate isothermal change and adiabatic change with *p*–*V* graphs and by means of the first law of thermodynamics

(*n*) derive and use the expression for work done in the thermodynamic process

16. Thermal conduction (*3 double periods*)

16.1 Thermal conductivity

16.2 Determination of thermal conductivity

Explanatory notes

Candidates should be able to

(*a*) explain the mechanism of heat conduction through solids and hence distinguish between conduction through metals and non-metals

(*b*) define thermal conductivity

(*c*) use the equation $\frac{Q}{t} = kA\,\frac{\theta_2 - \theta_1}{x}$ for heat conduction in one dimension

(*d*) describe quantitatively heat conduction through composite rods of different materials

(*e*) describe quantitatively heat conduction through rods which are not insulated

(*f*) understand the principle of determination of thermal conductivity for good conductors and poor conductors

E. ELECTRICITY AND MAGNETISM

17. Electrostatics (*3 double periods*)

17.1 Coulomb's law

17.2 Electric field

17.3 Gauss' law

17.4 Electrical potential

17.5 Equipotential surfaces

Explanatory notes

Candidates should be able to

(*a*) state Coulomb's law and use the formula $F = \frac{Qq}{4\pi\varepsilon_0 r^2}$

(*b*) understand electric field as an example an inverse square field like the gravitational field

(*c*) define the electric field strength, $E = F/q$

(*d*) describe quantitatively the motion of charges in a uniform electrical field

(*e*) state and use Gauss' law

(*f*) show the equivalence between Gauss' law and Coulomb's law

(*g*) use the relationship $E = -\frac{\mathrm{d}V}{\mathrm{d}r}$

(*h*) define electrical potential and use the formula $V = \frac{Q}{4\pi\varepsilon_0 r^2}$

(*i*) understand the relationship between electrical potential and potential energy

(*j*) understand equipotential surfaces

18. Capacitors (*4 double periods*)

18.1 Capacitance

18.2 Parallel plate capacitor

18.3 Uniform field between parallel plates

18.4 Capacitors in series and in parallel

18.5 Energy stored in a charged capacitor

18.6 Charging and discharging

18.7 Dielectrics

Explanatory notes

Candidates should be able to

(*a*) define capacitance and use the formula $C = \dfrac{Q}{V}$

(*b*) describe qualitatively the mechanism of charging a parallel plate capacitor

(*c*) derive and use the formula $C = \dfrac{\varepsilon A}{d}$ for parallel plate capacitors

(*d*) derive and use the formula for effective capacitance of capacitors in series and in parallel

(*e*) use the formulae $U = \dfrac{1}{2}QV$, $U = \dfrac{1}{2}\dfrac{Q^2}{C}$, $U = \dfrac{1}{2}CV^2$ (*Derivations are not required*.)

(*f*) describe quantitatively the charging and discharging of a capacitor through a resistor

(*g*) understand lightning as an example of discharging

(*h*) describe qualitatively the action of a dielectric in a parallel plate capacitor

19. Electric current (*5 double periods*)

19.1 Conduction of electricity

19.2 Drift velocity

19.3 Current density

19.4 Electrical conductivity

19.5 Resistivity

19.6 Dependence of resistance on temperature

19.7 Energy and electrical power

Explanatory notes

Candidates should be able to

(*a*) understand electric current as a flow of charged particles and use the equation $I = \mathrm{d}Q/\mathrm{d}t$

(*b*) explain qualitatively the mechanism of conduction of electricity in metals and semiconductors

(*c*) understand the concept of drift velocity

(*d*) derive and use the equation $I = Anev$

(*e*) know the typical orders of magnitude of drift velocity of charge carriers in semiconductors and metals (*f*) define electric current density and conductivity

(*g*) understand and use the relationship $J = \sigma E$

(*h*) derive and use the equation $\sigma = \frac{ne^2 t}{m}$

(*i*) define resistivity, $\rho = \frac{RA}{l}$

(*j*) show the equivalence between Ohm's law and the relationship $J = \sigma E$

(*k*) understand the dependence of resistance on temperature for metals and semiconductors by using the equation $\sigma = \frac{ne^2 t}{m}$

(*l*) know the phenomenon of superconductivity

(*m*) use the equations of energy and electrical power

20. Direct current circuits (*5 double periods*)

20.1 Electromotive force

20.2 Internal resistance of sources

20.3 Kirchhoff's law

20.4 Potential divider

20.5 Potentiometer

20.6 Wheatstone bridge

20.7 Shunt and multiplier

Explanatory notes

Candidates should be able to

(*a*) understand e.m.f. and electrical potential difference

(*b*) know that the sources of e.m.f. have internal resistance and understand the effect on external circuits

(*c*) draw and interpret electric circuit diagrams

(*d*) understand and use Kirchhoff's law

(*e*) understand how to use a potential divider

(*f*) understand the working principles of a potentiometer and its use

(*g*) understand the working principles of a Wheatstone bridge and its use

(*h*) understand the use of shunts and multipliers

21. Magnetic fields (*6 double periods*)

21.1 Magnetic field *B*

21.2 Force on a moving charge

21.3 Force on a current-carrying conductor

21.4 Magnetic fields due to currents

21.5 Force between current-carrying conductors

21.6 Definition of ampere: current balance

21.7 Torque on a coil

21.8 Determination of ratio q/m

21.9 Hall effect

Explanatory notes

Candidates should be able to

(*a*) understand the concept of magnetic field

(*b*) use the formula for force on a moving charge, $\vec{F} = q\vec{v} \times \vec{B}$

(*c*) use the equation $F = qvB \sin\theta$ to define magnetic field strength B

(*d*) understand the magnetic force that acts on a straight current-carrying conductor in a uniform magnetic field

(*e*) use the equation $F = IlB \sin\theta$

(*f*) use the formulae for magnetic fields:

circular loop, $B = \dfrac{\mu_0 NI}{2r}$

solenoid, $B = \mu_0 nI$

straight wire, $B = \dfrac{\mu_0 I}{2\pi d}$

(*g*) derive and use the formula $\dfrac{F}{l} = \dfrac{\mu_0 I_1 I_2}{2\pi d}$ for the force between two parallel current-carrying conductors

(*h*) define the unit of ampere and understand that this definition fixes a value for μ_0

(*i*) understand the working principles of a current balance and its physical significance as an absolute measurement

(*j*) derive the formula $\tau = NIBA$ for torque on a coil in a radial field

(*k*) explain the working principles of a moving-coil galvanometer and motor

(*l*) understand the motion of charge in magnetic fields and electrical fields

(*m*) understand the principles of determination of the ratio q/m for charged particles

(*n*) explain the Hall effect and derive the expression for Hall Voltage V_H

(*o*) describe the use of Hall effect

22. Electromagnetic induction (*6 double periods*)

22.1 Magnetic flux

22.2 Faraday's law and Lenz's law

22.3 Self-inductance L

22.4 Energy stored in a inductor

22.5 Mutual induction

22.6 Transformer

22.7 Back e.m.f. in dc motors

Explanatory notes

Candidates should be able to

(*a*) define magnetic flux $\Phi = BA\cos\theta$

(*b*) state and use Faraday's law and Lenz's law

(*c*) derive and use the equation for induced e.m.f. in linear conductors, discs, and plane coils

(*d*) explain the phenomenon of self-inductance and define self-inductance

(*e*) use the formulae $E = -L\frac{\mathrm{d}I}{\mathrm{d}t}$, $LI = N\Phi$

(*f*) derive and use the equation for self-inductance of a solenoid

(*g*) derive and use the formula for energy that is stored in a inductor

(*h*) explain the phenomenon of mutual induction and define mutual inductance

(*i*) derive an expression for mutual inductance between two coaxial coils

(*j*) derive and use the equation $\frac{V_\mathrm{s}}{V_\mathrm{p}} = \frac{N_\mathrm{s}}{N_\mathrm{p}}$ for a transformer

(*k*) discuss eddy currents in a transformer

(*l*) understand the concept of back e.m.f. in dc motors

23. Alternating currents (*3 double periods*)

23.1 Alternating currents through resistors

23.2 Power

23.3 R.m.s. value

23.4 Alternating currents through inductors

23.5 Alternating currents through capacitors

23.6 Rectification of alternating currents

23.7 Smoothing by capacitors

Explanatory notes

Candidates should be able to

(*a*) understand the concept of r.m.s. value of an alternating current and calculate the value; use the relationship $I_{\text{r.m.s.}} = I_0/\sqrt{2}$ for sinusoidal cases

(*b*) understand the relationship of phase between current and voltage for pure resistors, pure capacitors, and pure inductions separately (*c*) derive the reactance of a pure capacitor and a pure inductor

(*d*) derive and use the formula for power in an alternating current circuit which consists of a pure resistor, a pure capacitor, and a pure inductor separately

(*e*) explain half-wave rectification and full-wave rectification with the use of diodes

(*f*) explain smoothing of output voltages by capacitors

24. Electronics (*4 double periods*)

24.1 Operational amplifiers

24.2 Inverting and non-inverting amplifiers

24.3 Negative feedback

24.4 Use of operational amplifiers

24.5 Oscillators

Explanatory notes

Candidates should be able to

(*a*) understand the operational amplifier as a differential amplifier

(*b*) describe ideal properties of an operational amplifier

(*c*) describe the inverting amplifier and non-inverting amplifier

(*d*) understand the principle of feedback in an amplifier especially negative feedback

(*e*) describe the use of operational amplifiers in the circuits of voltage amplifiers, i.e. inverting amplifiers and non-inverting amplifiers, voltage comparators, integrators, and oscillators

F. OPTICS

25. Electromagnetic waves (*1 double period*)

25.1 Electromagnetic vibrations

25.2 Relationship between ε_0, μ_0, and c

25.3 Electromagnetic wave spectrum

Explanatory notes

Candidates should be able to

(*a*) understand that electromagnetic waves are made up of electrical vibrations, $E = E_0 \sin(\omega t - kx)$, and magnetic vibrations, $B = B_0 \sin(\omega t - kx)$

(*b*) understand that E, B, and the direction of propagation of electromagnetic waves are always perpendicular to each other

(*c*) compare electromagnetic waves with mechanical waves

(*d*) state the formula $c = \frac{1}{\sqrt{\varepsilon_0 \mu_0}}$ and explain its significance

(*e*) state the orders of magnitude of wavelengths and frequencies for each type of electromagnetic wave

26. **Geometrical optics** (*3 double periods*)

26.1 Curved mirrors

26.2 Refraction at curved surfaces

26.3 Thin lenses

Explanatory notes

Candidates should be able to

(*a*) understand and use the relationship $f = \frac{r}{2}$ for curved mirrors

(*b*) draw ray diagrams to show the formation of images by concave mirrors and convex mirrors

(*c*) derive and use the formula $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ for curved mirrors

(*d*) derive and use the formula $\frac{n_1}{u} + \frac{n_2}{v} = \frac{n_2 - n_1}{r}$ for refraction at spherical surfaces

(*e*) use the formula $\frac{n_1}{u} + \frac{n_2}{v} = \frac{n_2 - n_1}{r}$ to derive:

thin lens formula $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$

lens maker's formula $\frac{1}{f} = (n-1)\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$

(*f*) use the thin lens formula and lens maker's formula

27. **Physical optics** (*6 double periods*)

27.1 Huygens' principle

27.2 Interference

27.3 Two-slit interference pattern

27.4 Air wedge

27.5 Thin film

27.6 Diffraction at single slit

27.7 Diffraction gratings

27.8 Polarisation

Explanatory notes

Candidates should be able to

(*a*) understand and use the Huygens' principle to explain interference and diffraction phenomena

(*b*) understand the concept of coherence

(*c*) understand the concept of optical path difference

(*d*) know the conditions for constructive interference and destructive interference

(*e*) know Young's two-slit interference pattern (*f*) derive and use the formula $y = \frac{\lambda D}{a}$ for Young's interference pattern

(*g*) understand the formation of air wedge interference pattern and solve related problems

(*h*) understand the phenomena of thin film interference for nearly normal incident light and non-normal incident light, and solve related problems

(*i*) know the diffraction pattern for a single slit

(*j*) derive and use the formula $\sin\theta = \frac{\lambda}{a}$ for the first minimum in the diffraction pattern for a single slit

(*k*) know the diffraction pattern for diffraction gratings

(*l*) use the formula $d\sin\theta = n\lambda$ for diffraction gratings

(*m*) describe the use of diffraction gratings to form the spectrum of white light and measure the wavelength of monochromatic light

(*n*) understand that polarisation is a property of transverse waves

(*o*) understand the production of polarised light by polaroid and by reflection

(*p*) understand polarisation planes

(*q*) use the formula $I = I_0 \cos^2\theta$

G. QUANTUM PHYSICS

28. Photons (*2 double periods*)

28.1 Photoelectric effect

28.2 Concept of light quantisation

Explanatory notes

Candidates should be able to

(*a*) describe important observations in photoelectric emission experiments

(*b*) recognise features of photoelectric emission that cannot be explained by wave theory and explain these features using the concept of quantisation of light

(*c*) use the equation $E = hf$ for a photon

(*d*) understand the meaning of work function and threshold frequency

(*e*) use Einstein's equation for photoelectric effect, $hf = W + \frac{1}{2}mv^2$

(*f*) understand the meaning of stopping potential and use $eV_s = \frac{1}{2}mv^2$

29. Wave-particle duality (*1 double period*)

29.1 De Broglie relation

29.2 Electron diffraction

Explanatory notes

Candidates should be able to

(*a*) use the equation $\lambda = \frac{h}{p}$ to calculate de Broglie wavelength

(*b*) describe observations in electron diffraction experiments

(*c*) explain briefly the advantages of electron microscopes

H. ATOMIC PHYSICS

30. Atomic structure (*2 double periods*)

30.1 Bohr's postulate

30.2 Energy levels in atoms

30.3 Line spectra

Explanatory notes

Candidates should be able to

(*a*) state Bohr's postulate for an atom

(*b*) derive an expression for radii of orbits in Bohr's model

(*c*) derive the equation $E_n = -\frac{Z^2 e^4 m}{8 \varepsilon_0^2 h^2 n^2}$ for Bohr's model

(*d*) explain the production of line spectra with reference to transitions between energy levels

(*e*) understand the concept of excitation energy and ionisation energy

31. X-ray (*2 double periods*)

31.1 X-ray spectra

31.2 X-ray diffraction

Explanatory notes

Candidates should be able to

(*a*) interpret X-ray spectra obtained from X-ray tubes

(*b*) explain the characteristic line spectrum and continuous spectrum including $\lambda_{\min}$ in X-ray

(*c*) derive and use the equation $\lambda_{\min} = \frac{hc}{eV}$

(*d*) describe Bragg diffraction by crystals

(*e*) derive and use $2d \sin\theta = n\lambda$

32. Laser (*1 double period*)

32.1 Principles of production

32.2 Characteristics

32.3 Uses

Explanatory notes

Candidates should be able to

(*a*) describe briefly the principles of laser production

(*b*) describe the main characteristics of laser and advantages of laser

(*c*) describe a few examples of uses of laser

I. NUCLEAR PHYSICS

33. Nucleus (*2 double periods*)

33.1 Discovery of neutrons

33.2 Atomic number and mass number

33.3 Mass defect and binding energy

33.4 Isotopes

33.5 Mass spectrometry

Explanatory notes

Candidates should be able to

(*a*) describe the discovery of neutrons

(*b*) understand the symbol $^{A}_{Z}X$

(*c*) understand and use the units u and eV

(*d*) explain mass defect and binding energy

(*e*) understand the equivalence of mass with energy and use the formula $E = mc^2$

(*f*) understand the variation of binding energy per nucleon with nucleon number

(*g*) understand the existence of isotopes

(*h*) understand the working principles of mass spectrometers

34. Radioactivity (*2 double periods*)

34.1 Radioactive decay

34.2 Decay constant and half-life

34.3 Use of radioisotopes

Explanatory notes

Candidates should be able to

(*a*) understand radioactive decay as a spontaneous and random process

(*b*) state and use the exponential law $\frac{dN}{dt} = -\lambda N$ for radioactive decay

(*c*) define activity and decay constant

(*d*) derive and use the formula $N = N_0 e^{-\lambda t}$

(*e*) define half-life and derive the relation $\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

(*f*) explain the use of radioisotopes as tracers

35. Nuclear reaction (*2 double periods*)

35.1 Nuclear reaction

35.2 Nuclear fission

35.3 Nuclear fusion

Explanatory notes

Candidates should be able to

(*a*) understand that charge and nucleon number are conserved in nuclear reactions

(*b*) write and complete equations for nuclear reactions

(*c*) understand the principle of conservation of energy to calculate the energy released in a nuclear reaction

(*d*) understand the processes of nuclear fission and fusion

(*e*) understand the occurrence of fission and fusion in terms of binding energy per nucleon

(*f*) explain the conditions for a chain reaction to occur

(*g*) understand a controlled fission process in a reactor

(*h*) describe a nuclear fusion process which occurs in the sun

36. Elementary particles (*2 double periods*)

36.1 Basic forces

36.2 Quarks

36.3 Neutrinos

Explanatory notes

Candidates should be able to

(*a*) know the existence of four basic forces: gravitational force, electromagnetic force, nuclear strong force, and nuclear weak force

(*b*) know the classification of elementary particles into leptons and hadrons based on the action of basic forces

(*c*) understand quarks as constituents of protons and neutrons

(*d*) know that quarks have fractional charge

(*e*) describe the existence of neutrinos in beta decay

Practical Syllabus

The Physics practical course for STPM should achieve its objective to improve the quality of students in the aspects as listed below.

1. The ability to follow a set or sequence of instructions
2. The ability to plan and carry out experiments using appropriate methods
3. The ability to choose suitable equipment and use them correctly and carefully

4. The ability to determine the best range of readings for more detailed and careful measurements
5. The ability to make observations, to take measurements, and to record data with attention given to precision, accuracy, and units
6. The awareness of the importance of check readings and repeat readings
7. The awareness of the limits of accuracy of observations and measurements
8. The ability to present data and information clearly in appropriate forms
9. The ability to interpret, analyse, and evaluate observations and experimental data, and make deductions
10. The ability to make conclusions
11. The awareness of the safety measures which need to be taken

School-based Assessment of Practical (Paper 3)

School-based assessment of practical work will only be carried out during the school term of form six for candidates from government and private schools which have been approved by the Malaysian Examinations Council to carry out the school-based assessment. *Individual private candidates, candidates from private schools which have no permission to carry out the school-based assessment of practical work, candidates who repeat upper six (in government or private schools), and candidates who do* **not** *attend classes of lower six and upper six in two* **consecutive** *years (in government or private schools) are* **not** *allowed to enter for this paper.*

The Malaysian Examinations Council will determine 15 compulsory experiments to be carried out by candidates and to be assessed by subject teachers in school. Details of the topic, aim, theory, apparatus, and method of each of the experiments will be compiled and distributed to all schools.

Students should be supplied with a work scheme before the day of the compulsory experiment so as to enable them to plan their practical work. Each experiment is expected to last one school double period. Assessment of the students' practical work will be done by the teacher during the practical session and will also be based on the students' practical report. The assessment should comply with the assessment guidelines prepared by the Malaysian Examinations Council.

Written Practical Test (Paper 4)

Individual private candidates, candidates from private schools which have no permission to carry out the school-based assessment of practical work, candidates who repeat upper six (in government or private schools), and candidates who do **not** attend classes of lower six and upper six in two **consecutive** years (in government or private schools) are required to enter for this paper.

Two structured questions on routine practical work and/or design of experiments will be set. The Malaysian Examinations Council will not be strictly bound by the syllabus in setting questions. Where appropriate, candidates will be given sufficient information to enable them to answer the questions. Only knowledge of theory within the syllabus and knowledge of usual laboratory practical procedures will be expected.

Questions to be set will test candidates' ability to

(*a*) record readings from diagrams of apparatus;

(*b*) describe, explain, suggest, design, or comment on experimental arrangements, techniques, and procedures;

(*c*) complete tables of data and plot graphs;

(*d*) interpret, draw conclusions from, and evaluate observations and experimental data;

(*e*) recognise limitations of experiments and sources of results;

(*f*) explain the effect of errors on experimental results;

(*g*) suggest precautions or safety measures;

(*h*) explain theoretical basis of experiments;

(*i*) use theory to explain or predict experimental results;

(*j*) perform simple calculations based on experiments.

Time Allocation for the Syllabus

The time allocation for this syllabus is proposed to be 200 double periods (1 double period = 2 × 40 minutes), that is 170 double periods for the teaching/learning of theory and 30 double periods for practical work. Out of the 170 double periods for the teaching/learning of theory, 120 double periods are allotted for teaching topics and subtopics as detailed in the syllabus content, and 50 double periods are allotted for conducting tutorials. It is proposed that the time for tutorials for each topic is allotted as follows.

Topic	*Total double periods on tutorial*
A. Mechanics	15
B. Waves	3
C. Properties of matter	2
D. Thermodynamics	5
E. Electricity and magnetism	15
F. Optics	4
G. Quantum physics	1
H. Atomic physics	2
I. Nuclear physics	3
Total	50

Form of Examination

Candidates are required to enter for Papers 1, 2, and either Paper 3 or Paper 4.

Paper	*Format of paper*	*Marks*	*Duration*
Paper 1	50 compulsory multiple-choice questions to be answered.	50 (to be scaled to 60)	1¾ hours
Paper 2	*Section A:* 7 to 8 compulsory short structured questions to be answered. *Section B:* 4 questions to be answered out of 6 essay questions.	40 60 (15 per question) Total: 100 (to be scaled to 120)	2½ hours
Paper 3	School-based Assessment of Practical: 15 compulsory experiments to be carried out.	20	School term
Paper 4	Written Practical Test: 2 compulsory structured questions to be answered.	30 (to be scaled to 20)	1 hour

Summary of Key Quantities

Candidates will be expected to be familiar with the following quantities, their symbols, their units, and their interrelationships. They should also be able to perform calculations and deal with questions involving these quantities as indicated in the detailed syllabus. The list should not be considered exhaustive.

QUANTITY	*USUAL SYMBOLS*	*USUAL UNIT*
Basic quantities		
Mass	m	kg
Length	l	m
Time	t	s
Electric current	I	A
Thermodynamic temperature	T	K
Amount of material	n	mol
Other quantities		
Distance	d	m
Displacement	s, x	m
Area	A	m^2
Volume	V	m^3
Density	ρ	$kg\ m^{-3}$
Speed	u, v	$m\ s^{-1}$
Velocity	u, v	$m\ s^{-1}$
Acceleration	a	$m\ s^{-2}$
Acceleration of free fall	g	$m\ s^{-2}$
Force	F	N

Weight	W	N
Momentum	p	N s
Work	W	J
Energy	E, U	J
Potential energy	U	J
Heat	Q	J
Change of internal energy	ΔU	J
Power	P	W
Pressure	p	Pa
Torque	τ	N m
Gravitational constant	G	N kg^{-2} m^2
Gravitational field strength	g	N kg^{-1}
Gravitational potential	V	J kg^{-1}
Moment of inertia	I	kg m^2
Angular displacement	θ	°, rad
Angular speed	ω, $\dot{\theta}$	rad s^{-1}
Angular velocity	ω, $\dot{\theta}$	rad s^{-1}
Angular acceleration	α, $\ddot{\theta}$	rad s^{-2}
Angular momentum	L	kg m^2 rad s^{-1}
Period	T	s
Frequency	f, ν	Hz
Angular frequency	ω	rad s^{-1}

QUANTITY	*USUAL SYMBOLS*	*USUAL UNIT*
Wavelength	λ	m
Speed of electromagnetic waves	c	m s^{-1}
Electric charge	Q, q	C
Elementary charge	e	C
Current density	J	A m^{-2}
Surface charge density	σ	C m^{-2}
Electric potential	V	V
Electric potential difference	V	V
Electromotive force	ε, E	V
Resistance	R	Ω
Resistivity	ρ	Ω m
Conductance	G	$S = \Omega^{-1}$
Conductivity	σ	$S\ m^{-1} = \Omega^{-1}m^{-1}$
Electric field strength	E	N C^{-1}
Permittivity	ε	F m^{-1}
Permittivity of free space	ε_0	F m^{-1}
Relative permittivity	ε_r	
Capacitance	C	F
Time constant	τ	s
Magnetic flux	Φ	Wb
Magnetic flux density	B	T
Self inductance	L	H
Mutual inductance	M	H
Reactance	X	Ω
Impedance	Z	Ω
Permeability	μ	H m^{-1}
Permeability of free space	μ_0	H m^{-1}
Relative permeability	μ_r	
Force constant	k	N m^{-1}

Young modulus	E	Pa
Tension	T	N
Normal stress	σ	Pa
Refractive index	n	
Critical angle	θ_c	°
Focal length	f	m
Object distance	u	m
Image distance	v	m
Magnification power	M	
Temperature	t, θ	°C
Celsius temperature	t	°C
Heat capacity	C	$J\ K^{-1}$
Specific heat capacity	c	$J\ K^{-1}\ kg^{-1}$
Latent heat	L	J
Special latent heat	l	$J\ kg^{-1}$
Molar heat capacity	C_m	$J\ K^{-1}\ mol^{-1}$
Principal molar heat capacities	$C_{V,m}$; $C_{p,m}$	$J\ K^{-1}\ mol^{-1}$
Molar gas constant	R	$J\ K^{-1}\ mol^{-1}$
Boltzmann constant	k	$J\ K^{-1}$
Avogadro constant	L, N_A	mol^{-1}
Number density	n	m^{-3}

QUANTITY	*USUAL SYMBOLS*	*USUAL UNIT*
Thermal conductivity	k, λ	$W\ m^{-1}\ K^{-1}$
Planck constant	h	J s
Work function	ϕ, W	J
Activity of radioactive source	A	s^{-1}, Bq
Decay constant	λ	s^{-1}
Half life	$t_{½}$	s
Atomic mass	m_a	kg
Relative atomic mass	A_r	
Electron mass	m_e	kg, u
Neutron mass	m_n	kg, u
Proton mass	m_p	kg, u
Molar mass	M	$kg\ mol^{-1}$
Unified atomic mass constant	u	kg
Relative molecular mass	M_r	
Atomic number (proton number)	Z	
Mass number (nucleon number)	A	
Neutron number	N	

Note

A list of fundamental physical constants as shown below will be provided for Papers 1 and 2. These data are included in the Data Booklet for STPM. Other data, specific to individual questions, will be given with the individual questions.

960 PHYSICS
Values of constants

Speed of light in free space	c	=	3.00×10^{8} m s^{-1}
Permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
Permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}

		≈	$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
Magnitude of electronic charge	e	=	1.60×10^{-19} C
Planck constant	h	=	6.63×10^{-34} J s
Unified atomic mass constant	u	=	1.66×10^{-27} kg
Rest mass of electron	m_e	=	9.11×10^{-31} kg
Rest mass of proton	m_p	=	1.67×10^{-27} kg
Molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
Avogadro constant	L, N_A	=	6.02×10^{23} mol^{-1}
Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
Gravitational constant	G	=	6.67×10^{-11} N m^2 kg^{-2}
Acceleration of free fall	g	=	9.81 m s^{-2}

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