Physics Syllabus

MET 2021 Test Details

- Mode: Online Remote Proctored Test (RPT)
- Test Duration: **120** minutes
- Total Questions: **60**
    - **Multiple Choice Questions (MCQs):** Mathematics (15), Physics (10), Chemistry (10), and English (10)
    - **Numerical Answer Type (NAT):** Mathematics (5), Physics (5), and Chemistry (5)
- Max Marks: **240**
- Marking Scheme
    - **MCQ: +4** for every correct answer, **-1** for every wrong answer, **0** for every unanswered question
    - **NAT: +4** for every correct answer, **0** for every wrong, **0** for every unanswered question
- MET 2021 Schedule: June 11 – 14, 2021
    - There will be ONE attempt only

PHYSICS

Physical World and Measurement

Physical World: Physics-scope and excitement; nature of physical laws; Physics, technology and society, **Units and Measurements:** Need for measurement: Units of measurement; systems of units; SI units, fundamental and derived units. Length, mass and time measurements; accuracy and precision of measuring instruments; errors in measurement; significant figures. Dimensions of physical quantities, dimensional analysis and its applications.

Kinematics

Motion in a Straight Line: Elementary concepts of differentiation and integration for describing motion, uniform and non- uniform motion, average speed and instantaneous velocity, uniformly accelerated motion, velocity - time and position-time graphs. Relations for uniformly accelerated motion, **Motion in a Plane:** Scalar and vector quantities; position and displacement vectors, general vectors and their notations; equality of vectors, multiplication of vectors by a real number; addition and subtraction of vectors, relative velocity, Unit vector; resolution of a vector in a plane, rectangular components, Scalar and Vector product of vectors. Motion in a plane, cases of uniform velocity and uniform acceleration-projectile motion, uniform circular motion.

Laws of Motion: Intuitive concept of force, Inertia, Newton's first law of motion; momentum and Newton's second law of motion; impulse, Newton's third law of motion, Law of conservation of linear momentum and its applications, Equilibrium of concurrent forces, Static and kinetic friction, laws of friction, rolling friction, lubrication, Dynamics of uniform circular motion: Centripetal force, examples of circular motion

Work, Energy and Power: Work done by a constant force and a variable force; kinetic energy, work-energy, theorem, power, Notion of potential energy, potential energy of a spring, conservative forces: conservation of mechanical energy (kinetic and potential energies); non-conservative forces: motion in a vertical circle; elastic and inelastic collisions in one and two dimensions.

Motion of System of Particles and Rigid Body

System of Particles and Rotational Motion: Centre of mass of a two-particle system, momentum conservation and centre of mass motion. Centre of mass of a rigid body; centre of mass of a uniform rod. Moment of a force, torque, angular momentum, law of conservation of angular momentum and its applications, Equilibrium of rigid bodies, rigid body rotation and equations of rotational motion, comparison of linear and rotational motions, Moment of inertia, radius of gyration, values of moments of inertia for simple geometrical objects

Gravitation: Universal law of gravitation. Acceleration due to gravity (recapitulation only) and its variation with altitude and depth, Gravitational potential energy and gravitational potential, escape velocity, orbital velocity of a satellite, Geo-stationary satellites.

Mechanical Properties of Solids: Stress-strain relationship, Hooke's law, Young's modulus, bulk modulus**, Mechanical Properties of Fluids:** Pressure due to a fluid column; Pascal's law and its applications (hydraulic lift and hydraulic brakes), effect of gravity on fluid pressure. Viscosity, Stokes' law, terminal velocity, streamline and turbulent flow, critical velocity, Bernoulli's theorem and its applications. Surface energy and surface tension, angle of contact, excess of pressure across a curved surface, application of surface tension ideas to

drops, bubbles and capillary rise, **Thermal Properties of Matter:** Heat, temperature, (recapitulation only) thermal expansion; thermal expansion of solids, liquids and gases, anomalous expansion of water; specific heat capacity; Cp, Cv - calorimetry; change of state - latent heat capacity. Heat transfer-conduction, convection and radiation, thermal conductivity, qualitative ideas of Blackbody radiation, Wein's displacement Law, Stefan's law, Greenhouse effect.

Thermodynamics: Thermal equilibrium and definition of temperature (zeroth law of thermodynamics), heat, work and internal energy. First law of thermodynamics, isothermal and adiabatic processes. Second law of thermodynamics: reversible and irreversible processes

Behaviour of Perfect Gases and Kinetic Theory of Gases

Kinetic Theory: Equation of state of a perfect gas, work done in compressing a gas. Kinetic theory of gases - assumptions, concept of pressure. Kinetic interpretation of temperature; rms speed of gas molecules; degrees of freedom, law of equipartition of energy (statement only) and application to specific heat capacities of gases; concept of mean free path, Avogadro's number.

Oscillations: Periodic motion - time period, frequency, displacement as a function of time, periodic functions, Simple harmonic motion (S.H.M) and its equation; phase; oscillations of a loaded spring restoring force and force constant; energy in S.H.M. Kinetic and potential energies; simple pendulum derivation of expression for its time period. Free, forced and damped oscillations (qualitative ideas only), resonance, **Waves:** Wave motion: Transverse and longitudinal waves, speed of travelling wave, displacement relation for a progressive wave, principle of superposition of waves, reflection of waves, standing waves in strings and organ pipes, Beats

Electrostatics

Electric Charges and Fields: Electric Charges; Conservation of charge, Coulomb's law-force between two-point charges, forces between multiple charges; superposition principle and continuous charge distribution. Electric field, electric field due to a point charge, electric field lines, electric dipole, electric field due to a dipole, torque on a dipole in uniform electric field. Electric flux, statement of Gauss's theorem and its applications to find field due to infinitely long straight wire, uniformly charged infinite plane sheet.

Electrostatic Potential and Capacitance: Electric potential, potential difference, electric potential due to a point charge, a dipole and system of charges; equipotential surfaces, electrical potential energy of a system of two-point charges and of electric dipole in an electrostatic field. Conductors and insulators, free charges and bound charges inside a conductor. Dielectrics and electric polarisation, capacitors and capacitance, combination of capacitors in series and in parallel, capacitance of a parallel plate capacitor with and without dielectric medium between the plates, energy stored in a capacitor.

Current Electricity

Current Electricity: Electric current, flow of electric charges in a metallic conductor, drift velocity, mobility and their relation with electric current; Ohm's law, electrical resistance, V-I characteristics (linear and non-linear), electrical energy and power, electrical resistivity and conductivity; temperature dependence of resistance. Internal resistance of a cell, potential difference and emf of a cell, combination of cells in series and in parallel, Kirchhoff's laws and simple applications, Wheatstone bridge, metre bridge (qualitative ideas only) Potentiometer - principle and its applications to measure potential difference and for 14 comparing EMF of two cells; measurement of internal resistance of a cell (qualitative ideas only)

Magnetic Effects of Current and Magnetism

Moving Charges and Magnetism: Concept of magnetic field, Oersted's experiment. Biot - Savart law and its application to current carrying circular loop. Ampere's law and its applications to infinitely long straight wire. Straight and toroidal solenoids (only qualitative treatment), force on a moving charge in uniform magnetic and electric fields Force on a current-carrying conductor in a uniform magnetic field, force between two parallel current-carrying conductors-definition of ampere, torque experienced by a current loop in uniform magnetic field; moving coil galvanometer-its current sensitivity and conversion to ammeter and voltmeter.

Magnetism and Matter: Current loop as a magnetic dipole and its magnetic dipole moment, magnetic dipole moment of a revolving electron, bar magnet as an equivalent solenoid, magnetic field lines; earth's magnetic field and magnetic elements.

Electromagnetic Induction and Alternating Currents

Electromagnetic Induction: Electromagnetic induction; Faraday's laws, induced EMF and current; Lenz's Law, Eddy currents. Self and mutual induction. Alternating currents, peak and RMS value of alternating current/voltage; reactance and impedance; LC oscillations (qualitative treatment only), LCR series circuit, resonance; power in AC circuits AC generator and transformer.

Electromagnetic Waves: Electromagnetic waves, their characteristics, their Transverse nature (qualitative ideas only). Electromagnetic spectrum (radio waves, microwaves, infrared, visible, ultraviolet, X-rays, gamma rays) including elementary facts about their uses.

Optics: Ray Optics and Optical Instruments: Ray Optics, Refraction of light, total internal reflection and its applications, optical fibres, refraction at spherical surfaces, lenses, thin lens formula, lensmaker's formula, magnification, power of a lens, combination of thin lenses in contact, refraction of light through a prism. Optical instruments: Microscopes and astronomical telescopes (reflecting and refracting) and their magnifying powers.

Wave Optics Wave optics: Wave front and Huygen's principle, reflection and refraction of plane wave at a plane surface using wave fronts. Proof of laws of reflection and refraction using Huygen's principle. Interference, Young's double slit experiment and expression for fringe width, coherent sources and sustained interference of light, diffraction due to a single slit, width of central maximum

Dual Nature of Radiation and Matter: Dual nature of radiation, Photoelectric effect, Hertz and Lenard's observations; Einstein's photoelectric equation-particle nature of light, Experimental study of photoelectric effect: Matter waves-wave nature of particles, de-Broglie relation

Atoms: Alpha-particle scattering experiment; Rutherford's model of atom; Bohr model, energy levels, hydrogen spectrum, **Nuclei Composition and size of nucleus**: Nuclear force Mass-energy relation, mass defect, nuclear fission, nuclear fusion.

Electronic Devices

Semiconductor Electronics: Materials, Devices and Simple Circuits Energy bands in conductors, semiconductors and insulators (qualitative ideas only) Semiconductor diode - I-V characteristics in forward and reverse bias, diode as a rectifier; Special purpose p-n junction diodes: LED, photodiode, solar cell

Physics Previous Year Paper

16. The dimensions of $\frac{a}{b}$ in the equation $P = \frac{a - t^2}{bx}$ where P is pressure, x is distance and t is time are

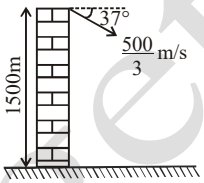
(a) $[M^2LT^{-3}]$ (b) $[MT^{-2}]$ (c) $[ML^3T^{-1}]$ (d) $[LT^{-3}]$

17. The coordinates of a particle moving at any time t is given by $x = 2At^2$ and $y = 2Bt^2$ where A and B are constants. The speed of the particle is

(a) $4t\,(A + B)$ (b) $4t\sqrt{A^2 + B^2}$

(c) $4t\,(A^2 + B^2)$ (d) $2t\sqrt{A^2 + B^2}$

18. A particle is projected from a tower as shown in figure, then the distance from the foot of the tower where it will strike the ground will be (take $g = 10$ m/s^2)



(a) 4000/3 m (b) 5000/3 m

(c) 2000 m (d) 3000 m

19. The force required to just move a body up the inclined plane is twice the force required to just prevent the body from sliding down the plane. If μ is the coefficient of friction, the inclination of the plane to the horizontal is

(a) $\tan^{-1}\left(\frac{\mu}{2}\right)$ (b) $\tan^{-1}(\mu)$

(c) $\tan^{-1}(2\mu)$ (d) $\tan^{-1}(3\mu)$

20. A wind-powered generator converts wind energy into electric energy. Assume that the generator converts a fixed fraction of the wind energy intercepted by its blades into electrical energy. For wind speed v, the electrical power output will be proportional to

(a) v (b) v^2 (c) v^3 (d) v^4

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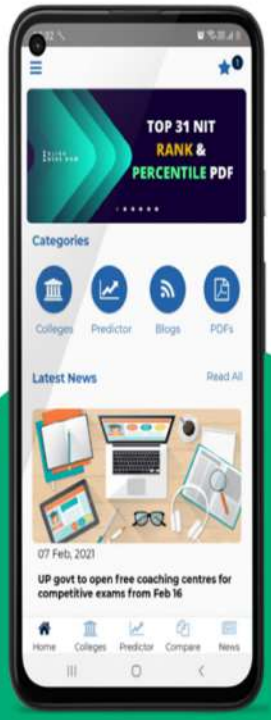

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21. A sphere of mass m moving with a constant velocity u hits another stationary sphere of the same mass. If e is the coefficient of restitution, then the ratio of velocities of the two spheres after collision will be

(a) $\left(\frac{1-e}{1+e}\right)$ (b) $\left(\frac{1+e}{1-e}\right)$

(c) $\left(\frac{e+1}{e-1}\right)$ (d) $\left(\frac{e-1}{e+1}\right)$

22. A pencil placed vertically on a table falls down. What will be the linear velocity of middle of pencil at the end of the fall if the pencil is 15 cm long?

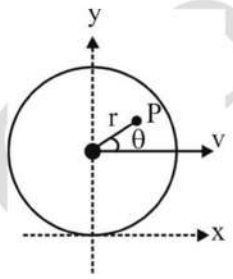
(a) 1.05 m/s (b) 2.1 m/s

(c) 3 m/s (d) 0.5 m/s

23. A billiard ball is hit by a cue at a height h above the centre. It acquires a linear velocity v_0. Mass of the ball is m and radius is r. The angular velocity ω_0 acquired by the ball is

(a) $\frac{2v_0h}{5r^2}$ *(b)* $\frac{5v_0h}{2r^2}$ (c)(c) $\frac{2v_0r^2}{5h}$ (d)(d) $\frac{5v_0r^2}{2h}$

24. A disc of radius R rolls without slipping at speed v along positive x-axis. Velocity of point P at the instant shown in figure is



(a) $\vec{V}_P = \left(v + \frac{vr\sin\theta}{R}\right)\hat{i} + \frac{vr\cos\theta}{R}j$ (b) $\vec{V}_P = \left(v + \frac{vr\sin\theta}{R}\right)\hat{i} - \frac{vr\cos\theta}{R}j$

(c) $\vec{V}_P = \frac{vr\sin\theta}{R}\hat{i} + \frac{vr\cos\theta}{R}j$ (d) $\vec{V}_P = \frac{vr\sin\theta}{R}\hat{i} - \frac{vr\cos\theta}{R}j$

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25. Two particles of mass m and M are initially at rest and infinitely separated from each other. Due to mutual interaction they approach each other. Their relative velocity of approach at a distance of separation d between them is

(a) $2G\left(\frac{d}{M+m}\right)$ (b)(b) $\sqrt{\left[\frac{2G(M+m)}{d}\right]}$

(c)(c) $\sqrt{\left[\frac{2G(M-m)}{d}\right]}$ (d)(d) $\sqrt{\left(\frac{2Gd}{M+m}\right)}$

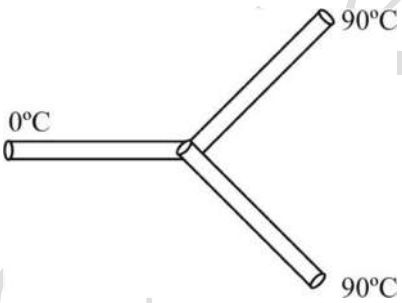
26. A cylinder of mass m and density ρ hanging from a string is lowered into a vessel of cross-sectional area s containing a liquid of density σ (<ρ) until it is fully immersed. The increase in pressure at the bottom of the vessel is

(a) $\frac{m\rho g}{\sigma s}$ *(b)* $\frac{mg}{s}$ *(c)* $\frac{m\sigma g}{\rho s}$ (d) zero

27. The frequency of a sonometer wire is f. When the weights producing the tensions are completely immersed in water the frequency becomes $f/2$ and on immersing the weights in a certain liquid the frequency becomes $f/3$. The specific gravity of the liquid is

(a) $\frac{4}{3}$ (b) $\frac{16}{9}$ (c) $\frac{15}{12}$ (d) $\frac{32}{27}$

28. Three rods made of the same material and having the same cross-section have been joined as shown in the figure. Each rod is of the same length. The left and right ends are kept at 0ºC and 90ºC respectively. The temperature of junction of the three rods will be



(a) 45ºC (b) 60ºC (c) 30ºC (d) 20ºC

29. The mean density of sea water is ρ, and bulk modulus is B. The change in density of sea water in going from the surface of water to a depth of h is

(a) $\frac{B\rho^2}{gh}$ (b) $B\rho gh$ (c) $\frac{\rho^2 gh}{B}$ (d) $\frac{\rho gh}{B}$

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30. A uniform cylinder of length L and mass M having cross-sectional area A is suspended with its vertical length, from a fixed point by a massless spring, such that it is half-submerged in a liquid of density d at equilibrium position. When the cylinder is given a small downward push and released, it starts oscillating vertically with a small amplitude. If the force constant of the spring is K, the frequency of oscillation of the cylinder is

(a) $\frac{1}{2}\left(\frac{K-Adg}{M}\right)^{1/2}$

(b) $\frac{1}{2\pi}\left(\frac{K+dgL}{M}\right)^{1/2}$

(c) $\frac{1}{2\pi}\left(\frac{K+Adg}{M}\right)^{1/2}$

(d) $\frac{1}{2\pi}\left(\frac{K-Adg}{Adg}\right)^{1/2}$

31. An open pipe of length ℓ is sounded together with another open organ pipe of length $\ell + x$ in their fundamental tones. Speed of sound in air is v. The beat frequency heard will be ($x << \ell$)

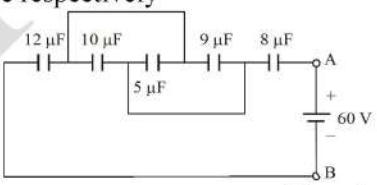
(a) $\frac{vx}{4\ell^2}$

(b) $\frac{v\ell^2}{2x}$

(c) $\frac{vx}{2\ell^2}$

(d) $\frac{vx^2}{2\ell}$

32. Five capacitors are connected as shown. The equivalent capacitance between terminals A and B and charge on 5μF capacitor will be respectively



(a) 8 μF, 100 μC

(b) 4 μF, 50 μC

(c) 12 μF, 150 μC

(d) 16 μF, 200 μC

33. A charge Q is distributed over two concentric hollow spheres of radii R and $2R$ such that the surface densities are equal. The potential at the common centre is

(a) $\frac{2}{3}\cdot\frac{Q}{4\pi\epsilon_0 R}$

(b) $\frac{3}{4}\cdot\frac{Q}{4\pi\epsilon_0 R}$

(c) $\frac{2}{5}\cdot\frac{Q}{4\pi\epsilon_0 R}$

(d) $\frac{3}{5}\cdot\frac{Q}{4\pi\epsilon_0 R}$

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34. A particle of charge q and mass m starts moving from the origin under the action of an electric field $\vec{E} = E_0\hat{i}$ and $\vec{B} = B_0\hat{i}$ with a velocity $\vec{v} = v_0\hat{j}$. The speed of the particle will become $\frac{\sqrt{5}}{2}v_0$ after a time

(a) $\frac{mv_0}{qE}$ (b) $\frac{\sqrt{q}mv_0}{2qE}$

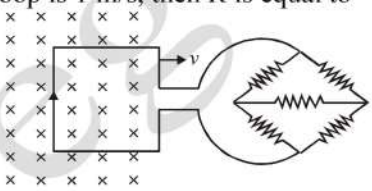
(c) $\frac{mv_0}{2qE}$ (d) $\frac{mv_0}{3qE}$

35. A large metal sheet carries an electric current along its surface. Current per unit length is λ. Magnetic field induction near the metal sheet is

(a) $\lambda\mu_0$ (b) $\frac{\lambda\mu_0}{2}$

(c) $\frac{\lambda\mu_0}{2\pi}$ (d) $\frac{\lambda}{\mu_0}$

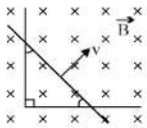
36. A square metal loop of side 20 cm and resistance 2 ohm is moved with a constant velocity partly inside a uniform magnetic field of 5 Wb/m^2, directed into the paper, as shown in the figure. The loop is connected to a network of five resistors each of value R. If a steady current of 0.1 A flows in the loop, and the speed of the loop is 1 m/s, then R is equal to



(a) 2 Ω (b) 3 Ω

(c) 8 Ω (d) 9 Ω

37. A conductor is bent in L-shape and another conductor is sliding with constant velocity v directed perpendicular to its length as shown in the figure. The sliding conductor always makes equal angle with the two arms of the bent conductor. If resistance per unit length of each conductor is r then current in the loop formed by conductors is



(a) $\frac{\sqrt{2}BV}{(\sqrt{2}+1)r}$ (b) $\frac{\sqrt{2}BV}{(\sqrt{2}+2)r}$

(c) $\frac{BV}{(\sqrt{2}+2)r}$ *(d)* $\frac{BV}{(\sqrt{2}+1)r}$

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38. In an ac circuit V = 100 sin (100 t) volt and I = 100 sin (100 t + $\pi/3$) mA. The power dissipated in the circuit is

(a) 10^4 W
(b) 10 W
(c) 2.5 W
(d) 5 W

39. A radioactive material has a mean life of 1620 years and 540 years for α and β emission respectively. The time in which one half of the material remains undecayed emitting both these radiations is

(a) 202.5 yrs
(b) 280.7 yrs
(c) 405 yrs
(d) 1080 yrs

40. A hydrogen atom in its ground state absorbs 10.2 eV of energy. Its orbital angular momentum is increased by (given $h = 6.6 \times 10^{-34}$ Js)

(a) 1.05×10^{-34} Js
(b) 3.16×10^{-34} Js
(c) 2.11×10^{-34} Js
(d) 4.22×10^{-34} Js

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Geometry – Area and Measurements

Question

Which of the following is the area of a circle with radius r?

- πr^2
- $2\pi r$
- πr
- $\frac{1}{2}\pi r^2$

Solution

The area of a circle is given by $A = \pi r^2$.

Geometry – Area of a Triangle

Question

Which of the following is the area of a triangle with base b and height h?

- $\frac{1}{2}bh$
- bh
- $2bh$
- $\frac{1}{3}bh$

Solution

The area of a triangle is $A = \frac{1}{2}bh$.

Geometry – Area of a Rectangle

Question

Which of the following is the area of a rectangle with length l and width w?

- lw
- $2lw$
- $\frac{1}{2}lw$
- $l + w$

Solution

The area of a rectangle is $A = lw$.

Geometry – Area of a Trapezoid

Question

Which of the following is the area of a trapezoid with bases b_1 and b_2 and height h?

- $\frac{1}{2}(b_1 + b_2)h$
- $(b_1 + b_2)h$
- $\frac{1}{2}b_1 b_2 h$
- $\frac{1}{3}(b_1 + b_2)h$

Solution

The area of a trapezoid is $A = \frac{1}{2}(b_1 + b_2)h$.

Geometry – Area of a Parallelogram

Question

Which of the following is the area of a parallelogram with base b and height h?

- bh
- $2bh$
- $\frac{1}{2}bh$
- $b + h$

Solution

The area of a parallelogram is $A = bh$.

Geometry – Area of a Rhombus

Question

Which of the following is the area of a rhombus with diagonals d_1 and d_2?

- $\frac{1}{2}d_1 d_2$
- $d_1 d_2$
- $2d_1 d_2$
- $\frac{1}{3}d_1 d_2$

Solution

The area of a rhombus is $A = \frac{1}{2}d_1 d_2$.

Geometry – Area of a Regular Polygon

Question

Which of the following is the area of a regular polygon with perimeter P and apothem a?

- $\frac{1}{2}Pa$
- Pa
- $2Pa$
- $\frac{1}{3}Pa$

Solution

The area of a regular polygon is $A = \frac{1}{2}Pa$.

Geometry – Area of a Circle

Question

Which of the following is the area of a circle with radius r?

- πr^2
- $2\pi r$
- πr
- $\frac{1}{2}\pi r^2$

Solution

The area of a circle is given by $A = \pi r^2$.

Geometry – Area of a Sector

Question

Which of the following is the area of a sector with radius r and central angle θ (in radians)?

- $\frac{1}{2}r^2\theta$
- $r^2\theta$
- $2r^2\theta$
- $\frac{1}{3}r^2\theta$

Solution

The area of a sector is $A = \frac{1}{2}r^2\theta$.

Geometry – Area of a Segment

Question

Which of the following is the area of a segment with radius r and central angle θ (in radians)?

- $\frac{1}{2}r^2(\theta - \sin\theta)$
- $r^2(\theta - \sin\theta)$
- $2r^2(\theta - \sin\theta)$
- $\frac{1}{3}r^2(\theta - \sin\theta)$

Solution

The area of a segment is $A = \frac{1}{2}r^2(\theta - \sin\theta)