

**FURTHER DETAILS REGARDING MAIN TOPICS OF  
PROGRAMME NO. 06/2014 (Item No.6)**

# **SENIOR MECHANIC**

## ***HARBOUR ENGINEERING***

**(CATEGORY NO. 79/2012)**

### **Part-I Questions based on Diploma in Mechanical Engineering**

#### **I. INDUSTRIAL MANAGEMENT**

**Principles of management:** Meaning of management – Taylor’s scientific management, Functions of management – Different types of ownership – Organizational structure.

**The principles of a good wage payment system:** Types of wages – Nominal, real, living, fair, and minimum wages – Incentives

**Quality Planning and its developments:** Definitions of quality– Dimensions of quality– TQM concept

**Project Management Techniques:** Introduction to Network analysis – Commonly used terms in CPM and PERT – CPM – Operation, earliest finish time (EFT), latest finish time (LFT), critical path, event, slack or float, dummy activity – Construction and numbering of network diagram – Fulkerson's rule – Simple problems on CPM (by AOA method only) – PERT - Comparison between CPM and PERT – Calculation of expected time – Event, activity, successor event, predecessor event, earliest expected time, latest allowable time, slack.

**Quantitative techniques in management:** Methods –Linear programming: - Formulation of LPP –Transportation problem – North West corner rule, Vogel's approximation method – Simple problems. – Game theory – Two-persons zero sum game – Maxi-min and mini-max principle – Saddle point – simple problems.

#### **Materials and sales management.**

Inventory management –definition and classification –purchase procedure –buying techniques –EOQ and ABC analysis.

Stores management –introduction –store keeping functions –duties of store keeper – store layout

Centralized and decentralized store –store records –indent forms –bincard –store ledger.

Sales –importance –functions of sales department –sales forecasting.

## **II. INDUSTRIAL ENGINEERING**

**Production planning and control:** Concepts of industry – Meaning of the term production and productivity – Methods of increasing productivity – Types of production – Job production batch production, mass production,

continuous production – Explanation of production planning control – Benefits and functions of PPC – Pre-planning activities – Forecasting, plant location, product planning, design and development, material selection,

Process planning, determination of men, machines, material and tool requirements – Process planning – Choice of machine in process planning – Break even analysis – Process sheet – Process planning procedure

Routing – Scheduling – Dispatching – Value Engineering – Plant location and layout – Factors to be considered in locating industrial plants – Plant layout – Types of layouts – Compare the advantages and disadvantages of each type – Plant maintenance – Types of maintenance.

**Method study:** Work study – Advantages and application of work study to increase productivity

Method study – Therbligs and their symbols – Process chart symbols – Preparation of operation process chart, flow process chart, man-machine chart, right hand left hand chart, and simo chart – Flow diagram – Principles of motion economy – Rules concerning human body, work place layout and material handling, tools and equipment design – Objectives of work measurement – Procedure of stop watch time study – Standard time calculation – Production study – Work sampling – Steps in work sampling.

**Inspection and Quality control:** Concept of quality and quality control – Product control – Concepts of inspection – Types of inspection – First piece inspection, working inspection, sample inspection, operation inspection, key operation inspection, floor or patrolling inspection, centralized inspection – Advantages and limitations

**Fundamental statistical concepts:** Explain the term variability in measurements – Explain the terms variable, attribute, frequency, frequency distribution and frequency plot – Normal distribution curve – Tally sheet – Explanation of the terms mean, mode, median and standard deviation – Calculation of mean, mode, median and standard deviation – Statistical quality control -- Types of control charts – X,R,P,100P, and C

**Project analysis:** Need and scope for project analysis - Explanation of the constituents elements of project analysis – Production cost – Market survey – Selling price – Capital investment – Return on, investment – Elements of costing – Classification of costs – Depreciation – Types of depreciation – Obsolescence – Basic formula for calculation of machining times for the operation such as turning, drilling and shaping – Simple problems.

### **III. METALLURGY AND MACHINE TOOLS**

#### **1. MATERIAL SCIENCE:**

**Metals and alloys:** Structure of materials – Structure of solids – Crystal structure – BCC , FCC and HCP -- Ferrous and non ferrous – Cast iron- White, malleable, grey and nodular cast iron –Manufacturing of Pig iron- Blast Furnace – Manufacturing of Cast iron - Cupola Furnace – Types of steel – Manufacturing of steel - Bessemer process, LD process, Open hearth and Electric furnace – Steel alloys -- Non ferrous metals and alloys - Aluminum, Copper and its alloys – Crucible furnace.

**Heat Treatment Processes:** Cooling curve for pure iron– iron carbon equilibrium diagram –TTT diagram – Micro constituents of steel -- Heat treatment process, annealing, normalizing, hardening, tempering, mar tempering, austempering, case hardening (cyaniding, nitriding and carburising ), age hardening—induction hardening – flame hardening -- residual stress due to heat treatment

**Properties, testing and inspection of materials:** Mechanical properties such as strength, hardness, toughness, brittleness, creep, fatigue, stiffness, ductility, malleability, elasticity and plasticity – Thermal properties such as specific heat, thermal conductivity, thermal resistance, and thermal diffusivity – Destructive testing --Tensile and compressive test – Hardness test: – Impact test – Fatigue test – Creep test – Non-destructive testing – Radio graphic – Ultrasonic testing – Inspection -- Spark test, magnetic particle, x-ray and dye penetration tests

#### **2. MANUFACTURING PROCESS.**

**Measuring instruments, gauges and comparators:** Classification of measuring instruments – Precision and non precision instruments – Direct reading and indirect measuring instruments — Vernier caliper, micrometer (inside, outside) - Classifications of gauges – Plug, ring, snap, screw pitch gauge, feeler gauge, standard wire gauge and indicating gauges –Comparators – Mechanical comparators, Electrical comparators, Optical comparators, Pneumatic comparators.

**Welding, soldering and brazing :** Arc welding –Principle of arc welding – Welding positions — Flat, horizontal , vertical and overhead welding – Welded joints – Butt, lap ,corner , tee ,edge ,V- joints, U-joint --Selection of welding electrodes – Electrode coatings – Functions of Electrode coating – Gas welding --Type of flames – Functions and operation of oxy –acetylene cylinders, pressure regulators, welding torch, nozzle – Explanation of submerged arc welding, tungsten inert gas (TIG) welding, metal inert gas (MIG) welding, Atomic hydrogen welding and thermit welding – Defects in welding – Causes and remedies of the defects such as porosity, poor penetration, warping, under cut, distortion crack, poor appearances - Soldering – Brazing.

**Foundry:** tools- rammer, trowel, slick, lifter, strike off bar, bellow, sprue pin, mallet, gate cutter, swab, vent rod, draw spike, moulding box – Composition of moulding sands – Types of moulding sand – Green sand, dry sand, parting sand, loom sand,

facing sand and core sand – Properties of molding sand such as porosity, plasticity, adhesiveness, cohesiveness, refractoriness. Types of patterns- single piece pattern, split pattern, match plate pattern, gated pattern, loose piece pattern, sweep pattern – Pattern allowances- shrinkage allowance, draft allowance, machining allowance, distortion or camber allowance, rapping allowance

**Bench work and fitting:** Fitting operations like chipping, filing, scraping, grinding, sawing, marking, drilling, reaming, tapping, dieing – Tools used in fitting- vice (bench vice, pipe vice, hand vice), files- various types of files-specification of files-chisels, hammers, hack saw, scrapers, punches, surface plate, surface gauge, V-block, angle plate, try square, combination set, steel rule, calipers(outside and inside), divider, scriber, drills, , reamer, tap and tap wrench, die and die stock, goggles.

### 3. MACHINE TOOLS

**Metal cutting :**Orthogonal cutting and oblique cutting, chip formation ,type of chips, cutting speed , feed and depth of cut --Tool life – Machinability

**Lathe and lathe work:** Type of lathe –Lathe parts, function of each part – Lathe accessories – Work holding and tool holding devices.– Speed, feed and depth of cut – Operations – taper turning methods, – Lathe specification

**Drilling machines:** Classification – Work holding devices – Types of drill bits – Tool holding devices – Operations.

**Shaping Machines :** General use of a shaper – Parts and their functions.

**Slotting Machines:** General use of a slotter – Slotter parts and their functions.

**Planing machines:** General use of a planer – Planner parts and their functions.

**Milling machines:** General use of milling machines – Parts of milling machines and their functions – Types of milling machines - Cutter holding devices (a) arbours (b) collets - Milling operations - plain milling, key and key ways, gang milling , T – slot milling – Milling methods (a) conventional milling (b) climb milling – Types of indexing.

**Broaching Machines:** General use of a broaching machines – Parts and their functions.

**Gear manufacture:** Method of making gears – Gear hobbling.

**Jigs and Fixtures:** Definition of jigs and fixtures.

**Grinding:** Abrasives- natural, artificial – Bonding materials -vitrified, silicate, shellac, rubber –

Kind of abrasives, grain size, grade and structure, kind of bond material, functions of the grinding wheels – Grinding machines – Cylindrical grinders.-centre type and centre less type grinders.

**Capston and turret lathe :** Construction and parts – tooling layout

**Automatic and copying machines :** Automation – definition

**Flexible manufacturing system :** Flexible automation – flexible manufacturing cell – components of FMS

**Robots and robotics :** Basic elements of robots – types of joints – robotic arms – robotic hands

**Computer Numerical Control (CNC):** Machine tools ( brief description only)

#### **IV: FLUID MECHANICS,PNEUMATICS AND HYDRAULIC MACHINES**

##### **1. FLUID MECHANICS AND PNEUMATICS**

**Properties of Fluids :**Density – specific weight – specific volume – specific gravity – problems – viscosity – kinematics viscosity –Newton’s law of viscosity – types of fluids – compressibility – surface tension – capillarity

**Fluid pressure and its measurement:** Fluid pressure at a point – pressure head – problems – Pascal’s law – absolute, gauge, atmospheric and vacuum pressures – simple problems – measurement of fluid pressure – Piezometer tube – simple manometer– differential manometer – inverted differential manometer – Bourdon’s tube pressure gauge – total pressure.

**Kinematics and Dynamics of fluid flow:** Introduction – types of fluid flow – steady and unsteady flow –uniform and non-uniform flow – laminar and turbulent flow – compressible and incompressible flow – rotational and ir-rotational flow – rate of flow or discharge – equation of continuity of a liquid flow – simple problems – energy of a liquid in motion – potential energy – kinetic energy – pressure energy – total energy – total head of liquid in motion – Bernoulli’s equation — practical applications of Bernoulli’s equation – venturimeter – Orifice meter – Pitot tube.

**Flow through Orifices, Notches, Pipes and Nozzles:** Orifices – types of orifices – Vena contracta – coefficient of contraction – coefficient of velocity – coefficient of discharge – Notches – types of notches – Flow through pipes – loss of head in pipes – major energy losses – minor energy losses – loss of energy due to friction – Darcy’s formulae(No derivation) for loss of head in pipes – Chezy’s formula (No derivation) for loss of head in pipes – simple problems – loss of head due to sudden enlargement – loss of head due to sudden contraction(No derivation) – water hammer -- nozzles .

**Fluid Power:** Introduction – Basic law – Applications of fluid power

**Hydraulic system:** Basic elements of hydraulic system – Oil reservoir pump unit – Principles of working of Positive displacement pump – Classifications – Gear pumps, Screw Pump, Vane pumps, Lobe pump, Simple piston pumps.

**Hydraulic control elements and components:** Control valves – Functions – classifications – Describe the working of pressure control valves such as relief valves – poppet valve – Direction control valves – check valves.

Flow control valves – types – gate, globe, butterfly valves, non return valve.

**Pneumatic System:** Comparison of pneumatic system with hydraulic system – identification of standard pneumatic symbols – basic pneumatic system – air filter – pressure regulator – lubricator – mufflers

**Pneumatic control elements and components:** Pneumatic control valves – Air cylinders.

## 2. HYDRAULIC MACHINES

**Impact of jets :** Force exerted by the jet – stationary – vertical – inclined – curved plate ( symmetrical and unsymmetrical ) – force exerted by the jet on moving plates – simple problems.

**Impulse turbines:** Development of water Turbines-classification-impulse Turbine-Pelton wheel Components.

**Reaction turbines:** Components—difference between impulse & Reaction— Classification of Reaction Turbines—Francis Turbine—Kaplan Turbine -Draft tubes – specific speed.

**Centrifugal pump:** Types of casing—piping system of CP—work done, manometric head—efficiencies—discharge—power required to drive –multistage pumps -specific speed of CP— cavitation—priming.

**Reciprocating pump:**Types –comparison of CP & RP –discharge—slip –air vessels , Hydraulic ram.

## V. APPLIED MECHANICS, STRENGTH OF MATERIALS AND DESIGN OF MACHINE ELEMENTS

### 1. APPLIED MECHANICS , STRENGTH OF MATERIALS (5 marks)

**Direct Stresses and strains:** Types of stresses and strains – tensile and compressive – longitudinal and lateral strain –Poisson's ratio – behaviour of mild steel under tension – stress strain diagram – limit of proportionality – elastic limit – yield point – ultimate stress – working stress – factor of safety – comparison of stress strain diagram of a mild steel and a brittle material– Hooks law and Young's modulus – principle of superposition – stresses in varying section – stresses in composite section – simple problems.

**Shear stress and shear strain:** Shear stress and strain – modulus of rigidity – volumetric strain, bulk modulus – simple problems

**Thermal Stress and strain:** Nature and magnitude of stresses due to change in temperature – total or partial prevention of expansion and contraction – temperature stress on composite bar– simple problems.

**Truss analysis :** Types of frames – formula for finding the redundancy—free body diagram – equilibrium – forces in various members of stress due to loading – method of joints and method of sections

**Friction:** Introduction – type of friction – static friction, dynamic friction, sliding friction, rolling friction, pivot friction, limiting friction, angle of friction, coefficient of friction, cone of friction – state laws of friction. – static friction and kinetic friction.

**Centre of gravity of sections:** Centroids – centre of gravity – axis of symmetry and axis of reference – methods to find center of gravity – simple geometric sections such as rectangle, triangle and circle. **Moment of inertia of sections:** Moment of inertia – radius of gyration.

**Riveted joints:** Types – lap joint – single riveted, double riveted ( chain and zigzag ) – butt joint – single cover single riveted, double cover single riveted – failure of riveted joints – failure of rivets – shearing and crushing – failure of plates – tearing across a row of rivets – tearing off plate at an edge – strength of rivet, plate and riveted joint – efficiency of a riveted joint. – caulking and Fullering operations.

**Welded joints:** welding terms – leg of the weld, size of the fillet weld,

throat thickness, effective length of the weld, side fillet weld and end fillet weld – strength of welded joints.

**Thin Cylinders:** Failures of thin cylinder – stresses in thin cylindrical shell – hoop stress – longitudinal stress.

**Torsion of circular shafts:** Torsion equation – strength equation for solid and hollow shaft ( no proof ) – power equation – polar moment of inertia.

**Springs:** Types of spring – leaf spring – helical springs.

**Shear force and bending moment:** Types of beams – cantilever beam, simply supported beam, over hanging beam, built in beam or fixed beam and continuous beam – types of loading — concentrated or point load, uniformly distributed load and uniformly varying load – shear force and bending moment diagrams – cantilever beams – point load, uniformly distributed load and combination of point load and uniformly distributed load – simply supported beam – point load, uniformly distributed load and combination of point load and uniformly distributed load – maximum bending moment on the section. – deflection of beams

**Columns and struts:** Column, strut, buckling load, equivalent length, slenderness ratio – types of columns – short column, medium size column, long column.

## 2. MACHINE DRAWING AND DESIGN OF MACHINE ELEMENTS

**Screw Threads:** Thread terminology– Forms of screw threads (Square thread, V thread) – Whitworth thread– British Association thread–American standard thread– Acme thread–ISO metric thread–square thread–single start and multi start threads– right hand and left hand threads–conventional representation of threads-bolted connection using standard proportions..

**Welded joints and piping layout:** Classification of welds- Elementary welding symbols -- Types of pipes – Methods of connecting pipes-pipe threads-Representation of pipe threads – Types of pipe joints – Single and double line orthographic symbols for pipe fittings and valves (flanged, screwed and welded joints).

**Limits, Fits and Tolerances:** Definition of limits, fits and tolerances.

**Surface Roughness:** Surface roughness terminology- surface roughness values, Grades and symbols.

**General design considerations:** General procedure – Design stress and working stress – factor of safety.—kinematic link – pair – chain – four bar chain – examples and applications – mechanism -- inversion

**Bolts, Nuts and Key:** Designation of screw threads – stresses in screwed fastenings due to static loading – initial stresses – stresses due to external forces – bolts of uniform strength – types of keys – forces acting on a sunk key – strength of a sunk key – calculation of key size using empirical proportions.

**Shafts:** Torsional stresses and strains – strength of solid and hollow shaft – design of shaft considering strength and rigidity– comparisons – power transmitted by shaft – Compare solid and hollow shaft in terms of their weight, strength and stiffness.

**Couplings:** Shaft couplings – requirement – types.

**Bearings:** Functions of bearings – classification of bearings – Radial bearings – thrust bearings – sliding contact bearings – rolling contact bearings.

**Cams:** Classification of followers and cams – motion of the followers – uniform velocity, simple harmonic motion – uniform acceleration and retardation – cam terminology – displacement diagrams.

**Governors and Flywheels:** Functions of the governors – types of governors – simple watt governor – porter governor – flywheels – comparison with governors –



coefficient of fluctuation of speed – fluctuation of energy – maximum fluctuation of energy – coefficient of fluctuation of energy.

**Belt Drives:** Types of belts – flat belt, circular belt or rope, V-belt – types of flat belt drives – open and crossed belt drive – compound belt drive – stepped or cone pulley drive – velocity ratio – slip – creep.

**Gears and Gear Trains:** Functions of gears – friction wheels – advantages and disadvantages of a gear drive – spur gear nomenclature – simple gear drive – velocity ratio – gear trains – simple gear train – compound gear train.

## **VI. THERMAL ENGINEERING**

### **THERMAL ENGINEERING**

**Air Standard Cycles:** Assumption, Air standard efficiency -- explanation with diagrams and derivation of air standard efficiency of Carnot Cycle, Otto cycle, Diesel cycle, dual combustion cycle

**Fuels & Combustion:** Classification of fuels-solid, liquid, & gaseous- Merits & demerits of various types of fuels -- Requirements of a good fuel.-- Calorific Value - combustion of fuel

**Testing of I.C. Engines:** Performance of I.C.Engines- testing- Indicated power, Brake Power, Friction Power, - Mechanical Efficiency- Indicated Thermal efficiency, Brake Thermal efficiency, Relative efficiency-Total fuel consumption & Specific Fuel Consumption-Morse test for Determination of I.P. of multi-cylinder engine- Heat balance sheet- problems

**Heat Transfer:** Heat Transfer- conduction, convection and radiation – Fourier's law – Thermal conductivity – Conduction through plane wall and composite wall– Black body concept – Stefan - Boltzman law -- Gray body concept – Newton Rikhman equation – free and forced convection

**Heat Exchangers:** Heat exchangers-Classification– Recuperator type and regenerative type, parallel flow, counter flow type & cross flow. – concept of over all heat transfer coefficient --LMTD

**Air Compressors:** construction and working of Air compressors- function of an air compressor- uses of compressed air -Classification of the air compressors- working of reciprocating compressors (single stage and two stage), rotary compressors - fans and blowers, centrifugal compressors and axial flow compressors. Mechanical efficiency & Volumetric efficiency

**Different systems of I C engines:** Fuel systems, - components – carburetion – functions of carburetor –working fuel systems of diesel engine –fuel filter – injector

and injection nozzle – ignition system — cooling system – classification of cooling system – radiators

I C engine lubrication system – forced system – governing systems– quantity governing – quality governing – hit and miss governing.

**Principles of Refrigeration:** Definition of refrigeration, concept of C.O.P, unit of Refrigeration. reversed carnot cycle- COP, Application of refrigeration,

**Vapour Compression Refrigeration systems:** Principles and working of a vapour compression system with the help of flow diagram. C.O.P of vapour compression systems.

**Refrigeration Equipments:** Compressors - Condensers – Evaporators - Expansion Devices: Capillary tube, Thermostatic expansion valve.

**Refrigerants:** Definition: Primary and secondary refrigerants, desirable properties of refrigerants

**Psychrometry:** Definition, Dry air, moist air, saturated, unsaturated and super saturated air, degree of saturation, dry bulb temperature, wet bulb temperature, dew point temperature.

**Psychrometric Processes:** Sensible heating, sensible cooling –humidifying, dehumidifying

**Air Conditioning:** Definition, factors affecting human comfort, effective temperature

**Air conditioning systems:** Classification – industrial, comfort air conditioning, working of summer air conditioning, winter and year round air conditioning.

## **Part-II Questions based on Engineering Mathematics**

- I. Matrices – Identification of Matrices, matrix operations, adjoint and inverse.
- II. Determinants – Evaluation of second and third order, minors and cofactors, solutions of simultaneous linear equation in three unknown using Cramer's rule.
- III. Binomial Series – Expansions using Binomial theorem.
- IV. Trigonometric functions – Signs of functions in each quadrant. Trigonometric values of angles, properties of trigonometric functions, applications of the identities  $\sin(A \pm B)$ ,  $\cos(A \pm B)$  and  $\tan(A \pm B)$ .
- V. Coordinate geometry – Equations to a straight line – slope – intercept form, intercept form; Angle between two lines, condition for two lines to be perpendicular, parallel.
- VI. Differentiation – Limits and continuity, derivatives of functions, equation to tangents and normals. Maxima and minima of functions of one variable.

- VII. Integration of functions – Integration of different types of functions.
- VIII. Applications of integration – Area bounded by a curve and X or Y axis, solutions of differential equations using the method of variable separable solutions of linear differential equations of first order.

### **Part-III Questions based on Basic Science (Physics & Chemistry)**

Questions based on Physics & Chemistry (Diploma level).

### **Part-IV General Knowledge, Current Affairs, India National Movements & Renaissance in Kerala and its Leaders**

Geography of India- Physical Features- Climate-Soils- Rivers- Famous Sites – Etc

Demography- Economic and Social Development-Poverty Alleviation-Economy and Planning-Etc

History of India- Period from 1857 to 1947- National Movement- Etc.

Important World, National and Regional Events related to the Political and Scientific fields, Sports, Cinema and Literature etc.

#### **Facts about Kerala**

Geographical Facts- Physical Features- Climate-Soils- Rivers- Famous Sites – Etc

#### **Renaissance of Kerala**

##### Important Events/ Movements/Leaders

Brahmananda Swami Sivayogi, Chattampi Swami, Sree Narayana Guru, Vagbhatananda, Thycaud Ayya, Ayya Vaikundar, Poikayil Yohannan (Kumara Guru), Ayyankali, Pandit Karuppan, Mannathu Padmanabhan, V.T.Bhattathirippad, Dr. Palpu, Kumaranasan, Vakkom Moulavi, Blessed Kuriakose Elias Chavara, Etc

***NOTE: - It may be noted that apart from the topics detailed above, questions from other topics prescribed for the educational qualification of the post may also appear in the question paper. There is no undertaking that all the topics above may be covered in the question paper.***