# TABLE OF CONTENTS

## I ISRO SCIENTIST 'SC' Previous years Question paper



## II ISRO TECHNICAL ASSISTANT

## SELECTION PROCESS

BE/B. Tech or equivalent qualification in first class with an aggregate minimum of 65% marks or CGPA 6.84/10. Candidates who meet the eligibility criteria will be short-listed to appear in the Written Test, which is scheduled to be conducted at twelve venues viz., Ahmedabad, Bengaluru, Bhopal, Chandigarh, Chennai, Guwahati, Hyderabad, Kolkata, Lucknow, Mumbai, New Delhi, and Thiruvananthapuram. However, ICRB reserves its rights to prescribe a higher cut-off on need basis. ICRB also reserves its rights to cancel any written test center and re-allot the candidates to any other test center. The call letters for the written test to the short-listed candidates will be sent only by e-mail. The written test paper consists of 80 objective type questions carrying equal marks. Based on the performance in the Written Test, candidates will be short-listed for interview, the schedule and venue of which will be notified by e-mail. Written test is only a first level screening and written test score will not be considered for final selection process. Final selection will be based on the performance of the candidates in the Interview and those who secure minimum 60% marks in the interview will be eligible for consideration for empanelment, in the order of merit.

## SYLLABUS

### 1. ENGINEERING MATHEMATICS

**Linear Algebra**: Matrix algebra, Systems of linear equations, Eigen values and eigenvectors.

**Calculus**: Functions of single variable, Limit, continuity and differentiability, Mean value theorems, Evaluation of definite and improper integrals, Partial derivatives, Total derivative, Maxima and minima, Gradient, Divergence and Curl, Vector identities, Directional derivatives, Line, Surface and Volume integrals, Stokes, Gauss and Green's theorems.

**Differential equations**: First order equations (linear and nonlinear), Higher order linear differential equations with constant coefficients, Cauchy's and Euler's equations, Initial and boundary value problems, Laplace transforms, Solutions of one-dimensional heat and wave equations and Laplace equation.

**Complex variables**: Analytic functions, Cauchy's integral theorem, Taylor and Laurent series.

**Probability and Statistics**: Definitions of probability and sampling theorems, Conditional probability, Mean, median, mode and standard deviation, Random variables, Poisson, Normal and Binomial distributions.

**Numerical Methods**: Numerical solutions of linear and non-linear algebraic equations Integration by trapezoidal and Simpson's rule, single and multi-step methods for differential equations.

## 2. APPLIED MECHANICS AND DESIGN

**Engineering Mechanics:** Equivalent force systems, free-body concepts, equations of equilibrium, trusses and frames, virtual work and minimum potential energy. Kinematics and dynamics of particles and rigid bodies, impulse and momentum (linear and angular), energy methods, central force motion.

**Strength of Materials:** Stress and strain, stress-strain relationship and elastic constants, Mohr's circle for plane stress and plane strain, shear force and bending moment diagrams, bending and shear stresses, deflection of beams torsion of circular shafts, thin and thick cylinders, Euler's theory of columns, strain energy methods, thermal stresses.

**Theory of Machines:** Displacement, velocity and acceleration, analysis of plane mechanisms, dynamic analysis of slider-crank mechanism, planar cams and followers, gear tooth profiles, kinematics and design of gears, governors and flywheels, balancing of reciprocating and rotating masses. **Vibrations:** Free and forced vibration of single degree freedom systems, effect of damping, vibration isolation, resonance, critical speed of rotors.

**Design of Machine Elements:** Design for static and dynamic loading, failure theories, fatigue strength; design of bolted, riveted and welded joints; design of shafts and keys; design of spur gears, rolling and sliding contact bearings; brakes and clutches; belt, ropes and chain drives.

## 3. FLUID MECHANICS AND THERMAL SCIENCES

**Fluid Mechanics:** Fluid properties, fluid statics, manometry, buoyancy; Control-volume analysis of mass, momentum and energy, fluid acceleration; Differential equation of continuity and momentum; Bernoulli's equation; Viscous flow of incompressible fluids; Boundary layer, Elementary turbulent flow; Flow through pipes, head losses in pipes, bends etc.

**Heat-Transfer:** Modes of heat transfer; One dimensional heat conduction, resistance concept, electrical analogy, unsteady heat conduction, fins; Dimensionless parameters in free and forced convective heat transfer, Various correlations for heat transfer in flow over flat plates and through pipes; Thermal boundary layer; effect of turbulence; Radiative heat transfer, black and grey surfaces, shape factors, network analysis; Heat exchanger performance, LMTD and NTU methods.

**Thermodynamics:** Zeroth, First and Second laws of thermodynamics; Thermodynamic system and processes; Irreversibility and availability; Behaviour of ideal and real gases, Properties of pure substances, calculation of work and heat in ideal processes; Analysis of thermodynamic cycles related to energy conversion; Carnot, Rankine, Otto, Diesel, Brayton and Vapour compression cycles.

**Power Plant Engineering:** Steam generators; Steam power cycles; Steam turbines; impulse and reaction principles, velocity diagrams, pressure and velocity compounding; Reheating and reheat factor; Condensers and feed heaters.

**I.C. Engines:** Requirements and suitability of fuels in IC engines, fuel ratings, fuel-air mixture requirements; Normal combustion in SI and CI engines; Engine performance calculations.

## EXAM PATTERN FOR SCIENTIST 'SC'

| | | |
|---|---|---|
| Type of Examination | : | Objective Type (Multiple Choice Questions) |
| No. of Questions | : | 80 Questions |
| Apportionment of marks | : | Each Question carries three marks |
| Duration of Examination | : | 90 minutes |
| Negative Marks for wrong answer | : | One mark |
| Maximum Marks | : | 240 |

## PREVIOUS YEARS CUT OFF FOR INTERVIEW

**Note:** In ISRO all candidates are considered as general category and a few seats for PWD candidates.

| S. No. | Year | Cut off |
|---|---|---|
| 1 | 2020 | 153 |
| 2 | 2018 | 185 |
| 3 | 2017 (Dec) | 120 |
| 4 | 2017 (May) | 139 |
| 5 | 2016 | 135 |
| 6 | 2015 | 131 |

## SUBJECTS WISE WEIGHTAGE FOR SCIENTIST 'SC'

| SI.NO. | Subject | Year of examination | | | | |
|---|---|---|---|---|---|---|
| | | 2006 | 2007 | 2008 | 2009 | 2010 |
| 1 | Strength of Materials | 24 | 36 | 36 | 30 | 24 |
| 2 | Engineering Mechanics | 33 | 30 | 18 | 18 | 21 |
| 3 | Fluid Mechanics | 42 | 48 | 39 | 45 | 36 |
| 4 | Heat and Mass Transfer | 15 | 15 | 42 | 12 | 36 |
| 5 | Thermodynamics | 24 | 18 | 6 | 15 | 15 |
| 6 | Power Plant Engineering | 6 | 3 | 3 | 0 | 0 |
| 7 | Refrigeration and Air Conditioning | 3 | 0 | 0 | 3 | 0 |
| 8 | Theory of Machines | 30 | 21 | 15 | 12 | 9 |
| 9 | Machine Design | 3 | 6 | 12 | 21 | 6 |
| 10 | Material science | 9 | 12 | 21 | 21 | 21 |
| 11 | Production Engineering | 9 | 15 | 30 | 33 | 57 |
| 12 | Industrial Engineering | 6 | 3 | 3 | 3 | 0 |
| 13 | Engineering Mathematics | 36 | 33 | 15 | 27 | 15 |
| | Total Marks | 240 | 240 | 240 | 240 | 240 |



| SI.NO. | Subject | Year of examination | | | | |
|---|---|---|---|---|---|---|
| | | 2011 | 2012 | 2013 | 2014 | 2015 |
| 1 | Strength of Materials | 36 | 24 | 39 | 51 | 33 |
| 2 | Engineering Mechanics | 21 | 18 | 12 | 15 | 12 |
| 3 | Fluid Mechanics | 45 | 48 | 42 | 63 | 30 |
| 4 | Heat and Mass Transfer | 12 | 12 | 30 | 24 | 33 |

## Previous Interview Questions and Answers:

1. **How the pressure can be measured by a manometer?**

   Liquid manometers measure differential pressure by balancing the weight of a liquid between two pressures. Light liquids such as water can measure small pressure differences; mercury or other heavy liquids are used for large pressure differences.

2. **Name the different forces present in a fluid flow. For the Euler's equation of motion, which forces are taken into consideration?**

   The important forces present in a moving liquid are Inertia Force, Viscous Force, Gravity Force, Surface Tension Force, Pressure Force and Elastic Force.The Euler's equation of motion, only gravity and pressure forces are taken into consideration.

3. **Explain the working principle of Orifice meter.**

   It works on the Differential Pressure Measurement principle. The liquid or gas whose flow rate is to be determined is passed through the orifice plate. This creates a pressure drop across the orifice plate which varies with the flow rate, resulting in a differential pressure between the outlet and inlet segments. This pressure drop is measured and is used to calculate the flow rate of the fluid or gas.

4. **Define boundary layer and boundary layer thickness.**

   Boundary layer is the thin layer of a flowing gas or liquid in contact with a surface This creates a thin layer of fluid near the surface in which the velocity changes from zero at the surface to the free stream value away from the surface. the thickness of the boundary layer is the distance from the wall to the point where the velocity is 99% of the "free stream" velocity.

5. **Define Hydraulic gradient line and Total energy line.**

   HGL: It is the locus of all the points representing piezometric head in a flow field i.e., the summation of pressure head and velocity head at various points.

   TEL: It is the locus of all the points representing the total energy in a flow field i.e., the summation of piezometric head and Datum head at various points. Total energy line is also known as Energy gradient Line.

6. **How governing of speed is done in Turbines?**

   Maintaining the constant speed of turbine at all loads is known as Governing. If the demanded load or consumption of electricity is more, the speed of the turbine decreases in the same way if the demanded load is less, then the speed of the turbine increases. At all demanded loads, in order to have constant speed of the turbine the following governing mechanism are used.

## Question paper-2006

**1.** In nodular iron, graphite is in the form of

A. Cementite
B. Free carbon
C. Flakes
D. Spheroids

**2.** Hardness of steel depends on

A. Amount of carbon it contains
B. The shape and distribution of the carbides in iron
C. Method of fabrication
D. Contents of alloying elements

**3.** Too high welding current in arc welding would result in

A. Excessive spatter, under cutting along edges, irregular deposits, wasted electrodes
B. Excessive piling up of weld metal, poor penetration, wasted electrodes
C. Too small bead, weak weld and wasted electrodes
D. Excessive piling up of weld metal, overlapping without penetration of edges, wasted electrodes

**4.** Which of the following processes would produce strongest components?

A. Hot rolling
B. Extrusion
C. Cold rolling
D. Forging

**5.** If a quantity $Q$ is dependent on three other quantities $q_1$, $q_2$ and $q_2$ related such that $Q = K \times (q_1)^{n_1} \times (q_2)^{n_2} \times (q_3)^{n_3}$ then overall error $\frac{\delta Q}{Q} =$

A. $n_1\left(\frac{\delta q_1}{q_1}\right) + n_2\left(\frac{\delta q_2}{q_2}\right) + n_3\left(\frac{\delta q_3}{q_3}\right)$

B. $\frac{1}{n_1}\left(\frac{\delta q_1}{q_1}\right) + \frac{1}{n_2}\left(\frac{\delta q_2}{q_2}\right) + \frac{1}{n_3}\left(\frac{\delta q_3}{q_3}\right)$

C. $\frac{\delta q_1}{q_1} + \frac{\delta q_2}{q_2} + \frac{\delta q_3}{q_3}$

D. $\left(\frac{\delta q_1}{q_1}\right)^{n_1} + \left(\frac{\delta q_2}{q_2}\right)^{n_2} + \left(\frac{\delta q_3}{q_3}\right)^{n_3}$

**6.** Which of the following has maximum hardness

A. Austenite
B. Pearlite
C. Troostite
D. Martensite

**7.** The main advantage of line organization is its

A. Effective command and control
B. Defined responsibilities at all levels
C. Rigid discipline in the organization
D. All of the above

**8.** The mathematical technique for finding the best use of limited resources in an optimum manner is known as

A. Operation research
B. Linear programming
C. Network analysis
D. Queuing theory

9. Which of the following errors are generally distributed in accordance with the Gaussian distribution

A. Controllable errors
B. Calibration errors
C. Avoidable errors
D. Random errors

**10.** $\frac{PL^3}{3EI}$ is the deflection under the load P of a cantilever beam (length L, modulus of elasticity E, moment of inertia $I$). The strain energy due to bending is

A. $\frac{P^2L^3}{3EI}$

B. $\frac{P^2L^3}{6EI}$

C. $\frac{P^2L^3}{4EI}$

D. $\frac{P^2L^3}{48EI}$

**11.** A mass m attached to a light spring oscillates with a period of 2 sec. If the mass is increased by 2 kg, the period increases by 1 sec. The value of m is

A. 1 kg
B. 1.6 kg
C. 2 kg
D. 2.4 kg

**12.** A short column of external diameter D and internal diameter d carries an external load W. The greatest eccentricity which the load can have without producing tension on the cross section of the column is

A. (D + d)/8
B. $(D^2 + d^2)/8$
C. $(D^2 + d^2)/8D$
D. $(D^2 + d^2)/8d$

**13.** If the radius of wire stretched by a load doubled, then its Young's modulus will

A. Be doubled
B. Be halved
C. Become four times
D. None of the above

**14.** Longitudinal stress in a thin cylinder subjected to internal pressure is

A. Half of the hoop stress
B. Twice the hoop stress
C. Equal to the hoop stress
D. One-fourth the hoop stress

**15.** Maximum deflection in cantilever due to pure bending moment M at its end is

A. $\frac{ML^2}{2EI}$

B. $\frac{ML^2}{3EI}$

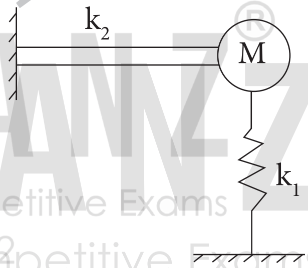
C. $\frac{ML^2}{4EI}$

D. $\frac{ML^2}{6EI}$

**16.** If Poisson's ratio for a material is 0.5, then the elastic modulus for the material is

A. 3 times its shear modulus
B. 4 times its shear modulus
C. Equal to its shear modulus
D. Indeterminate

**17.** A cantilever beam of negligible weight is carrying a mass M at its free end, and is also resting on an elastic support of stiffness $k_1$ as shown in the figure below. If $k_2$ represents the bending stiffness of the beam, the natural frequency (rad/s) of the system is




A. $\sqrt{\frac{k_1k_2(k_1+k_2)}{M}}$

B. $\sqrt{\frac{2(k_1+k_2)}{M}}$

C. $\sqrt{\frac{(k_1+k_2)}{M}}$

D. $\sqrt{\frac{(k_1-k_2)}{M}}$

**18.** The figure shows 3 small spheres that rotate

## ANSWER KEY - 2006

| Question | Answer | Question | Answer | Question | Answer | Question | Answer |
|---|---|---|---|---|---|---|---|
| 1 | **D** | 21 | **C** | 41 | **B** | 61 | **B** |
| 2 | **A** | 22 | **D** | 42 | **D** | 62 | **C** |
| 3 | **A** | 23 | **A** | 43 | **A** | 63 | **C** |
| 4 | **D** | 24 | **C** | 44 | **A** | 64 | **D** |
| 5 | **A** | 25 | **C** | 45 | **C** | 65 | **C** |
| 6 | **D** | 26 | **D** | 46 | **D** | 66 | **C** |
| 7 | **D** | 27 | **A** | 47 | **C** | 67 | **B** |
| 8 | **B** | 28 | **B** | 48 | **C** | 68 | **A** |
| 9 | **D** | 29 | **D** | 49 | **C** | 69 | **A** |
| 10 | **B** | 30 | **C** | 50 | **B** | 70 | **B** |
| 11 | **B** | 31 | **B** | 51 | **A** | 71 | **C** |
| 12 | **C** | 32 | **D** | 52 | **NA** | 72 | **B** |
| 13 | **D** | 33 | **A** | 53 | **D** | 73 | **B** |
| 14 | **A** | 34 | **B** | 54 | **D** | 74 | **A** |
| 15 | **A** | 35 | **A** | 55 | **C** | 75 | **C** |
| 16 | **A** | 36 | **D** | 56 | **D** | 76 | **C** |
| 17 | **C** | 37 | **B** | 57 | **B** | 77 | **C** |
| 18 | **D** | 38 | **D** | 58 | **B** | 78 | **C** |
| 19 | **A** | 39 | **B** | 59 | **D** | 79 | **B** |
| 20 | **A** | 40 | **B** | 60 | **C** | 80 | **A** |

## Solutions with Explanation 2006

1. Answer: **option (D)**

Nodular iron is also called ductile iron. The graphite is present as tiny balls or spheroids. Because the spheroids interrupt the matrix much less than graphite flakes, nodular cast iron has higher strength and toughness than gray cast iron. The formation of nodules or spheroids occurs when eutectic graphite separates from the molten iron during solidification.

2. Answer: **option (A)**

Hardness of steel depends on amount of carbon it contains.

3. Answer: **option (A)**

Too high welding current in arc welding would result in excessive spatter, under cutting along edges, irregular deposits, wasted electrodes.

4. Answer: **option (D)**

Forging processes would be used for producing strongest components.

5. Answer: **option (A)**

Given: $Q = k \times (q_1)^{n_1} \times (q_2)^{n_2} \times (q_3)^{n_3}$

$\ln Q = \ln K + n_1 \ln q_1 + n_2 \ln q_2 + n_3 \ln q_3$

Differentiating on both sides, we get

$$\frac{\delta Q}{Q} = n_1\left(\frac{\delta q_1}{q_1}\right) + n_2\left(\frac{\delta q_2}{q_2}\right) + n_3\left(\frac{\delta q_3}{q_3}\right)$$

6. Answer: **option (D)**

The most common method to harden a steel is annealing. It consists of heating to the austenizing temperature (hypoeutectoid steel) and cooling fast enough to avoid the formation of ferrite, pearlite or bainite, to obtain pure martensite. Martensite (α') has a distorted BCT (Body-Centered Tetragonal) structure. It is the hardest of all the structures. The higher hardness is obtained at 100% martensite. Martensite hardness depends solely on the carbon content of the steel. The higher the carbon content, the higher the hardness. Martensite is very brittle and cannot be used directly after quench for any application. Martensite brittleness can be reduced by applying a post-heat treatment known as - tempering.

7. Answer: **option (D)**

The main advantage of line organization is its

- Effective command and control
- Defined responsibilities at all levels
- Rigid discipline in the organization

8. Answer: **option (B)**

The mathematical technique for finding the best use of limited resources in an optimum manner is known as Linear programming.

9. Answer: **option (D)**

Random errors in experimental measurements are caused by unknown and unpredictable changes in the experiment. These changes may occur in the measuring instruments or in the environmental conditions.

Examples of causes of random errors are:

- electronic noise in the circuit of an electrical instrument,
- irregular changes in the heat loss rate from a solar collector due to changes in the wind.

Random errors often have a Gaussian normal distribution. In such cases statistical methods may be used to analyze the data.

10. Answer: **option (B)**

Given $\delta = \frac{PL^3}{3EI}$

The strain energy due to bending $\frac{1}{2}P\delta = \frac{P^2L^3}{6EI}$

11. Answer: **option (B)**

Given:

$m_1 = m$ kg, $m_2 = m + 2$ kg, $T_1 = 2$ sec, $T_2 = 3$ sec

Periodic time $T = 2\pi\sqrt{\frac{m}{k}}$

Where, m = Mass of the body in kg,

k = Stiffness of the spring in N/m i.e., restoring force per unit displacement from the equilibrium position,

$$\therefore 2 = 2\pi\sqrt{\frac{m}{k}} \text{ ---------- (i)}$$

$$\therefore 3 = 2\pi\sqrt{\frac{m+2}{k}} \text{ -------- (ii)}$$

Dividing equation (i) with (ii), and squaring on both sides, we get

$$\therefore \frac{4}{9} = \frac{m}{m+2}$$

$$m = 1.6 \text{ kg}$$

**12.** Answer: **option (C)**

Given: Tension on the cross section of the column is zero.

The resultant tensile stress

$$\sigma_t = \frac{M}{Z} - \frac{P}{A}$$

where, M = bending moment = P. e,

Z = sectionmodulus = $\frac{I}{y}$,

I = Moment of inertia = $\frac{\pi}{64}\sqrt{D^4 - d^4}$,

y = Distances of the extreme fibres from the neutral axis = $\frac{D}{2}$

As $\sigma_t$, by solving we get,

$$e = \frac{D^2 + d^2}{8D}$$

**13.** Answer: **option (D)**

Young's modulus is the material property not the geometric property. So, it will not change if the shape of material changes.

**14.** Answer: **option (A)**

$$\sigma_H = \frac{pd}{2t}$$

$$\sigma_L = \frac{pd}{4t} = \frac{\sigma_H}{2}$$

**15.** Answer: **option (A)**

Maximum deflection in cantilever due to pure bending moment M at its end is $\frac{ML^2}{2EI}$.

**16.** Answer: **option (A)**

Relation between elastic modulus (E) and shear modulus (G) is given by:

$E = 2G(1+\nu)$

$E = 2G(1 + 0.5)$

$\therefore E = 3G$

**17.** Answer: **option (C)**

The given system can be represented as two springs in parallel configuration.

When springs are connected in parallel, the equivalent stiffness is,

$K_{eq} = K_1 + K_2$

We have,

Natural frequency $(\omega_n) = \sqrt{\frac{k_{eq}}{M}} = \sqrt{\frac{K_1 + K_2}{M}}$ rad/sec

**18.** Answer: **option (D)**

rotational inertia for 36 kg mass

$= 36 \times 1^2 = 36 \text{ kg-m}^2$

rotational inertia for 9 kg mass

$= 9 \times 2^2 = 36 \text{ kg-m}^2$

rotational inertia for 4 kg mass

$= 4 \times 3^2 = 36 \text{ kg-m}^2$

**19.** Answer: **option (A)**

For simple harmonic oscillation, F = -kx

**20.** Answer: **option (A)**

Given: $K_1 = 20$ kN/m, $K_2 = 20$ kN/m, m = 100 kg.

When springs are connected in parallel, the equivalent stiffness is,

$K_{eq} = K_1 + K_2 = 40$ kN/m

We have,

Natural frequency $(\omega_n) = \sqrt{\frac{k_{eq}}{m}} = \sqrt{\frac{40 \times 10^3}{100}}$

$= 20$ rad/sec

Natural frequency $(f_n) = \frac{1}{2\pi}(\omega_n) = \frac{20}{2 \times \pi}$

$= \frac{10}{\pi}$ cycles/second

**21.** Answer: **option (C)**

The bending equation is written as:

$$\frac{M}{I} = \frac{f}{y} = \frac{E}{R}$$