Director’s Message

UPSC has introduced the sectional cutoffs of each paper and screening cut off in three objective papers (out of 600 marks). The conventional answer sheets of only those students will be evaluated who will qualify the screening cut offs.

In my opinion the General Ability Paper was easier than last year but Civil Engineering objective Paper-I and objective Paper-II both are little tougher/lengthier. Hence the cut off may be less than last year. The objective papers of ME and EE branches are average but E&T papers are easier than last year.

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<td>E&amp;T</td>
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</table>

**Note:** These are expected screening cut offs for ESE 2016. MADE EASY does not take guarantee if any variation is found in actual cutoffs.

*B. Singh (Ex. IES)*
CMD, MADE EASY Group

MADE EASY team has tried to provide the best possible/closest answers, however if you find any discrepancy then contest your answer at [www.madeeasy.in](http://www.madeeasy.in) or write your query/doubts to MADE EASY at: [info@madeeasy.in](mailto:info@madeeasy.in)

MADE EASY owes no responsibility for any kind of error due to data insufficiency/misprint/human errors etc.
MADE EASY offers well planned Classroom and Postal Study Course which is designed by senior and expert faculty members. MADE EASY announces exclusive batches for General Studies and Engineering Aptitude to cover the syllabus of Paper-I of Preliminary exam. The classes will be conducted by experienced faculties of MADE EASY focusing on new pattern of Engineering Services Examination, 2017. Latest and updated study material with effective presentation will be provided to score well in Paper-I.

Roadmap for ESE 2017 Prelims

Paper-I: General Studies & Engineering Aptitude

Course content

   Watch Video

2. **Reasoning and Aptitude**: Algebra and Geometry, Reasoning and Data Interpretation, Arithmetic, coding and decoding, Venn diagram, number system, ratio & proportion, percentage, profit & loss, simple interest & compound interest, time & work, time & distance, blood relationship, direction sense test, permutation & combinations etc.  
   Watch Video

   Watch Video
4. **General Principles of Design, Drawing, Importance of Safety**: Engineering Drawing, Drawing instruments, drawing standard, geometric construction and curves, orthographic projections, methods of projection, profile planes side views, projection of points, projection of straight lines, positions of a straight line with respect to HP and VP, determining true length and true inclinations of a straight line, rotation methods, trace of a line, projection of planes, importance of safety etc.


6. **Basics of Energy and Environment**: Renewable and non renewable energy resources, energy conservation, ecology, biodiversity, environmental degradation, environmental pollution, climate change, conventions on climate change, evidences of climate change, global warming, greenhouse gases, environmental laws for controlling pollution, ozone depletion, acid rain, biomagnification, carbon credit, benefits of EIA etc.

7. **Basics of Project Management**: Project characteristics and types, Project appraisal and project cost estimations, project organization, project evaluation and post project evaluation, risk analysis, project financing and financial appraisal, project cost control etc.

8. **Basics of Material Science and Engineering**: Introduction of material science, classification of materials, Chemical bonding, electronic materials, insulators, polar molecules, semi conductor materials, photo conductors, classification of magnetic materials, ceramics, polymers, ferrous and non ferrous metals, crystallography, cubic crystal structures, miller indices, crystal imperfections, hexagonal closed packing, dielectrics, hall effect, thermistors, plastics, thermoplastic materials, thermosetting materials, compounding materials, fracture, cast iron, wrought iron, steel, special alloys steels, aluminum, copper, titanium, tungsten etc.

9. **Information and Communication Technologies**: Introduction to ICT, Components of ICT, Concept of System Software, Application of computer, origin and development of ICT, virtual classroom, digital libraries, multimedia systems, e-learning, e-governance, network topologies, ICT in networking, history and development of internet, electronic mail, GPS navigation system, smart classes, meaning of cloud computing, cloud computing architecture, need of ICT in education, national mission on education through ICT, EDUSAT (Education satellite), network configuration of EDUSAT, uses of EDUSAT, wireless transmission, fibre optic cable etc.

10. **Ethics and values in engineering profession**: ethics for engineers, Ethical dilemma, elements of ethical dilemmas, indian ethics, ethics and sustainability, ethical theories, environmental ethics, human values, safety, risks, accidents, human progress, professional codes, responsibilities of engineers etc.
Classroom Course : Paper -1

Course Details : General Studies and Engineering Aptitude Batches

Course Duration : Regular batches : 2 months  |  Weekend batches : 3 months
Teaching Hours : 250-300 hours
Timings : Regular batches : 6-7 days a week and 4 hours a day.  |  Weekend batches : 8 hours everyday on Sat & Sun.
Study material : Well designed comprehensive study material including theory & Practice questions prepared by experienced faculty members will be provided

<table>
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<tr>
<th>Batch</th>
<th>Commencement Date</th>
<th>Venue</th>
<th>Timing</th>
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<td>2nd July, 2016</td>
<td>Saket / Lado Sarai (Delhi)</td>
<td>8:00 a.m. to 6:00 p.m.</td>
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<td>Regular Batch</td>
<td>1st July, 2016</td>
<td>MADE EASY Hyderabad</td>
<td>Evening Batch</td>
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</table>

**Note**: General Studies and Engineering Aptitude Batches will be commenced at all MADE EASY centres.
For latest updates and information keep visit: www.madeeasy.in

Postal Course

Postal Study Course for GS & Engineering Aptitude Paper-i will be available after 15th-July-2016
Buy online at : www.madeeasy.in

Fee Structure

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<tr>
<th>Non-MADE EASY Students</th>
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<tr>
<td>Those students who were enrolled in Postal Study Course, Rank Improvement, Conventional, G.S., Post GATE batches</td>
<td>Those students who were enrolled in long term classroom programs</td>
</tr>
</tbody>
</table>

| Rs. 18,500/- | Rs. 15,500/- | Rs.12,500/- |

Newly added technical subjects for ESE-2017

Interested students may join subjectwise classes for newly added technical subjects for ESE-2017

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<th>CE</th>
<th>ME</th>
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<td></td>
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<td>3. Advanced Communication</td>
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Fee Structure

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<tr>
<td>Rs. 6,500/- per subject</td>
<td>Rs.4,500/- per subject</td>
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Admission Open at all MADE EASY centres
Online admission facility available at : www.madeeasy.in

Corp. Office : 44 - A/1, Kalu Sarai, New Delhi - 110016; Ph: 011-45124612, 09958995830
1. Which one of the following helps experimental confirmation of the Crystalline state of matter?
   (a) Shock compression  (b) Photo emission  
   (c) Conductivity measurements  (d) X-ray diffraction

Answ. (d)

X-ray diffraction:
It is a rapid technique for analyzing wide range of materials. It can provide information about material phase or state and unit cell dimensions.

2. The electrical conductivity of pure semiconductor is
   (a) Proportional to temperature  
   (b) Increases exponentially with temperature  
   (c) Decreases exponentially with temperature  
   (d) Not altered with temperature

Answ. (a)

3. Consider the following statements pertaining to the resistance of a conductor:
   1. Resistance can be simply defined as the ratio of voltage across the conductor to the current through the conductor. This is, in fact, George Ohm’s law.
   2. Resistance is a function of voltage and current
   3. Resistance is a function of conductor geometry and its conductivity.

Which of the above statements are correct?
   (a) 1 and 2 only  (b) 2 and 3 only  
   (c) 1 and 3 only  (d) 1, 2 and 3

Answ. (c)

Resistance of conductor

\[ R = \frac{L}{\rho A} \]

where,
\[ R = \text{Resistance} \]
\[ \rho = \text{Resistivity of material} \]
\[ L = \text{Length of conductor} \]
\[ A = \text{Cross-sectional area of conductor} \]
4. The ratio of ionic radii of Cations i.e. $r_c$ and that of Anions i.e. $r_a$ for stable and unstable ceramic crystal structure, is
   (a) Less than unity (b) Greater than unity
   (c) Unity (d) Either lesser or greater than unity

Ans. (a)

- Ceramics are generally inorganic materials that consist of metallic and non-metallic elements.
- Cations are usually metals which are positively charged and smaller in size.
- Anions are usually non-metals with negative charge and bigger size.

\[ \frac{r_c}{r_a} = \text{Cation-radius} < \text{Anion-radius} < 1 \text{ (most of the cases).} \]

5. Which one of the following statements is correct?
   (a) For insulators the band-gap is narrow as compared to semiconductors it is narrow
   (b) For insulators the band-gap is relatively wide whereas for semiconductors it is narrow
   (c) The band-gap is narrow in width for both the insulators and conductors
   (d) The band-gap is equally wide for both conductors and semiconductors

Ans. (b)

\[ (\text{Band-gap})_{\text{insulator}} > (\text{Band gap})_{\text{semiconductor}} > (\text{Bandgap})_{\text{conductor}}. \]

6. In an extrinsic semiconductor the conductivity significantly depends upon
   (a) Majority charge carriers generated due to impurity doping
   (b) Minority charge carriers generated due to thermal agitation
   (c) Majority charge carriers generated due to thermal agitation
   (d) Minority charge carriers generated due to impurity doping

Ans. (a)

\[ \sigma = \text{Majority carrier concentration} \times \text{Magnitude of charge} \times \text{Mobility} \]
\[ \therefore \text{Majority carrier concentration} \propto \text{Doping concentration.} \]

7. Necessary condition for photoelectric emission is
   (a) $h\nu \geq e\phi$
   (b) $h\nu \geq mc$
   (c) $h\nu \geq e\phi^2$
   (d) $h\nu \geq \frac{1}{2}mc$

Ans. (a)
8. In some substances when an electric field is applied the substance becomes polarized. The electrons and nuclei assume new geometrical positions and the mechanical dimensions are altered. This phenomenon is called
   (a) Electrostriction  (b) Hall-Effect
   (c) Polarization  (d) Magnetization
   Ans. (a)
   **Electrostriction**: Change in the dimension or production of strain in material with application of electric field is known as electrostriction.

9. In ferromagnetic materials, the net magnetic moment created due to magnetization by an applied field is:
   (a) Normal to the applied field  (b) Adds to the applied field
   (c) In line with magneto motive force  (d) Subtracts from the applied field
   Ans. (b)
   In ferromagnetic material, the total magnetic flux density is summation of
   - flux density due to applied field
   - flux density due to magnetization
   i.e. $B = \mu_0H + \mu_0M$

10. At what temperatures domains lose their ferromagnetic properties?
    (a) Above ferromagnetic Curie temperature  (b) Below paramagnetic Curie temperature
    (c) Above 4° K  (d) At room temperature
    Ans. (a)
    Above ferromagnetic curie temperature, ferromagnetism disappear and material enters into its paramagnetic state.

11. Which of the following materials does not have paramagnetic properties?
    1. Rare earth elements (with incomplete shell)
    2. Transition elements
    3. Magnesium oxide
    Select the correct answer from the codes given below:
    (a) 1 only  (b) 2 only
    (c) 3 only  (d) 1 and 2
    Ans. (c)
    Magnesium oxide is a non-magnetic material where as rare earth elements and transition elements are magnetic material.
MADE EASY offers rank improvement batches for ESE 2017 & GATE 2017. These batches are designed for repeater students who have already taken regular classroom coaching or prepared themselves and already attempted GATE/ESE Exams, but want to give next attempt for better result. The content of Rank Improvement Batch is designed to give exposure for solving different types of questions within fixed time frame. The selection of questions will be such that the Ex. MADE EASY students are best benefitted by new set of questions.

**Features:**
- Comprehensive problem solving sessions
- Smart techniques to solve problems
- Techniques to improve accuracy & speed
- Systematic & cyclic revision of all subjects
- Doubt clearing sessions
- Weekly class tests
- Interview Guidance

**Eligibility:**
- Old students who have undergone classroom course from any centre of MADE EASY or any other Institute
- Top 6000 rank in GATE Exam
- Qualified in ESE written exam
- Qualified in any PSU written exam
- M. Tech from IIT/NIT/DTU with minimum 7.0 CGPA

**Syllabus Covered:** Technical Syllabus of GATE-2017 & ESE-2017

**Course Duration:** Approximately 25 weeks (400 teaching hours)

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<td>Weekend</td>
<td>Sat &amp; Sun : 8:00 a.m to 5:00 p.m</td>
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<td>ME</td>
<td>Regular</td>
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<td>4th July, 2016</td>
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<td>Those students who were enrolled in Postal Study Course, Rank Improvement, Conventional, G.S, Post GATE batches</td>
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<td>Rank Improvement Batch + General Studies &amp; Engineering Aptitude Batch</td>
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Fee is inclusive of classes, study material and taxes

Note:
1. These batches will be focusing on solving problems and doubt clearing sessions. Therefore if a student is weak in basic concepts & fundamentals then he/she is recommended to join regular classroom course.
2. Looking at the importance and requirements of repeater students, it is decided that the technical subjects which are newly added in ESE 2017 syllabus over ESE 2016 syllabus will be taught from basics and comprehensively.
3. The course fee is designed without Study Material/Books, General Studies and Online Test Series (OTS). However, those subjects of technical syllabus which are added in ESE-2017 will be supplemented by study material. Study Material/Books will be provided only for the technical syllabus which are newly added in ESE-2017.

**Rank Improvement Batches will be conducted at Delhi Centre only.**

Documents required:
- M.Tech marksheet
- PSUs/IES Interview call letter
- GATE score card
- MADE EASY I-card
- 2 photos + ID proof

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12. In a superconducting magnet, wires of superconducting material are embedded in the thick copper matrix, because while the material is in the superconducting state:
(a) The leakage current passes through copper part
(b) Copper part helps in conducting heat away from the superconductor
(c) Copper part helps in overcoming the mechanical stress
(d) Copper acts as an insulating cover for superconductor

Ans. (c)
Copper matrix helps in overcoming the mechanical stress when wire material is in superconducting state. When wire material enters to the normal state due to some accidental quarch than copper matrix takes over the job of wire material.

13. The crystal structure of some Ceramic materials may be thought of being composed of electrically charged Cations and Anions, instead of Atoms, and as such:
(a) The Cations are negatively charged, because they have given up their valence electrons to Anions which are positively charged.
(b) The Cations are positively charged, because they have given up their valence electrons to Anions which are negatively charged.
(c) The Cations are positively charged, because they have added one electron to their valence electrons borrowing from Anions which are negatively charged.
(d) The Cations are negatively charged, as they are non-metallic whereas Anions are positively charged being metallic.

Ans. (b)
Ceramics are generally in organic compounds that consists of cations and anions.
• Cations are usually, metals with positive charge.
• Anions are usually non-metals with negative charge.

14. Manganin alloy used for making resistors for laboratory instruments contains:
(a) Copper, Aluminium and Manganese
(b) Copper, Nickel and Manganese
(c) Aluminium, Nickel and Manganese
(d) Chromium, Nickel and Manganese

Ans. (b)
Manganin is an alloy of copper, Nickel and manganese.

15. A rolled-paper capacitor of value 0.02 µF is to be constructed using two strips of aluminium of width 6 cm, and, wax impregnated paper of thickness 0.06 mm whose relative permittivity is 3. The length of foil strips should be:
(a) 0.3765 m
(b) 0.4765 m
(c) 0.5765 m
(d) 0.7765 m
Ans. (d)

\[ C = 0.02 \mu F \]
\[ w = 6 \text{ cm} \]
\[ d = 0.06 \text{ mm} \]
\[ \epsilon_r = 3 \]
\[ C = \frac{\epsilon A}{d} \]

\[ \Rightarrow \quad A = \frac{Cd}{\epsilon} = \frac{0.02 \times 10^{-6} \times 0.06 \times 10^{-3}}{3 \times 8.854 \times 10^{-12}} \]

but
\[ A = L \times w = \frac{0.02 \times 10^{-6} \times 0.06 \times 10^{-3}}{3 \times 8.854 \times 10^{-12}} \]

\[ \Rightarrow \quad L \times 6 \times 10^{-2} = \frac{0.02 \times 10^{-6} \times 0.06 \times 10^{-3}}{3 \times 8.854 \times 10^{-12}} \]
\[ \Rightarrow \quad L = 0.7765 \text{ m} \]

16. A Ge sample at room temperature has intrinsic carrier concentration \( n_i = 1.5 \times 10^{13} \text{ cm}^{-3} \) and is uniformly doped with acceptor of \( 3 \times 10^{16} \text{ cm}^{-3} \) and donor of \( 2.5 \times 10^{15} \text{ cm}^{-3} \). Then, the minority charge carrier concentration is

(a) \( 0.918 \times 10^{10} \text{ cm}^{-3} \)  
(b) \( 0.818 \times 10^{10} \text{ cm}^{-3} \)  
(c) \( 0.918 \times 10^{12} \text{ cm}^{-3} \)  
(d) \( 0.818 \times 10^{12} \text{ cm}^{-3} \)

Ans. (b)

\[ P \text{ type compensated semiconductor} \]

Minority carrier concentration = \[ \frac{n_i^2}{N_A - N_D} = \frac{(1.5 \times 10^{13})^2}{(3 \times 10^{16} - 2.5 \times 10^{15})} \]

\[ = \frac{(1.5 \times 10^{13})^2}{2.75 \times 10^{16}} = 0.81818 \times 10^{10} / \text{cm}^3 \]

17. Assume that the values of mobility of holes and that of electrons in an intrinsic semiconductor are equal and the values of conductivity and intrinsic electron density are \( 2.32/\Omega \text{m} \) and \( 2.5 \times 10^{19} / \text{m}^3 \) respectively. Then, the mobility of electron/hole is approximately

(a) \( 0.3 \text{ m}^2/\text{Vs} \)  
(b) \( 0.5 \text{ m}^2/\text{Vs} \)  
(c) \( 0.7 \text{ m}^2/\text{Vs} \)  
(d) \( 0.9 \text{ m}^2/\text{Vs} \)
Ans.  (a) 
Since,  
\[ \mu_n = \mu_p \rightarrow \mu \]
\[ \sigma_i = n_i q \left[ 2\mu \right] \]
\[ \mu = \frac{\sigma_i}{2n_i q} = \frac{2.32}{2 \times (1.6 \times 10^{-19}) \times (2.5 \times 10^{19})} \]
\[ \mu = 0.29 \text{ m}^2/\text{V sec} \]
\[ \mu = \mu_n \text{ or } \mu_p \]

18. A silicon sample A is doped with \(10^{18}\) atom/cm\(^3\) of Boron and another silicon sample B of identical dimensions is doped with \(10^{18}\) atom/cm\(^3\) of Phosphorous. If the ratio of electron to hole mobility is 3, then the ratio of conductivity of the sample A to that of B is 
(a) \(\frac{3}{2}\)  
(b) \(\frac{2}{3}\)  
(c) \(\frac{1}{3}\)  
(d) \(\frac{1}{2}\)  
Ans.  (c) 
\[ \frac{\sigma_A}{\sigma_B} = \frac{\mu_p}{\mu_n} = \frac{1}{3} \]
MADE EASY
India’s Best Institute for IES, GATE & PSUs

Classroom Course is designed for comprehensive preparation of ESE, GATE & PSUs. The main feature of the course is that all the subjects are taught from basic level to advance level. There is due emphasis on solving objective and numerical questions in the class. High quality study material is provided during the classroom course with sufficient theory and practice test papers for objective and conventional questions along with regular assignments for practice. Classes are taken by highly experienced professors and ESE qualified toppers. MADE EASY team has developed very effective methodology of teaching and advance techniques and shortcuts to solve objective questions in limited time.

Course Features:
- Timely coverage of technical & non-technical syllabus
- Regular classroom tests followed by discussion
- Doubt clearing sessions
- Interview Guidance Program
- All India ESE Classroom Test Series

Syllabus Covered:
- All Technical Subjects along with 10 subjects of paper-I (as per revised syllabus of ESE 2017)
- Engineering Mathematics
- Reasoning & Aptitude

Books & Reading References:
- Technical Subjects (Theory Book + Work Book)
- Engineering Mathematics
- Reasoning & Aptitude
- Previous Years GATE Solved Papers
- General English
- Previous Years IES Solved Papers (Objective & Conventional)

Difference between Regular and Weekend Course:
In Regular Course, classes are conducted for 4 to 6 hours per day in a week for 8 to 9 months where as in Weekend Courses take 10 to 11 months for completion of syllabus as classes run nearly 8 to 9 hrs/day on every weekends and public holidays.

Streams Offered: CE, ME, EE, EC, CS, IN, PI

New Batches Commencing at Delhi Centres

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<td>EE : 30th May &amp; 5th June, 2016</td>
<td>ME from 28th May’16</td>
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<td>EC : 30th May &amp; 9th June, 2016</td>
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ADMISSIONS OPEN
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To know more about upcoming batches, Fee Structure, timing & other details, visit: www.madeeasy.in
Ans. (a)

Carrier concentration = \( \frac{1}{\alpha R_h} = \frac{1}{1.6 \times 10^{-19} \times 3.6 \times 10^{-4}} \)

\( = 0.173611 \times 10^{23}/m^3 = 2 \times 10^{22}/m^3 \)

21. What is the value of current \( I \) through the ideal diode in the circuit?

<table>
<thead>
<tr>
<th>Option</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>100 mA</td>
</tr>
<tr>
<td>(b)</td>
<td>150 mA</td>
</tr>
<tr>
<td>(c)</td>
<td>200 mA</td>
</tr>
<tr>
<td>(d)</td>
<td>250 mA</td>
</tr>
</tbody>
</table>

Ans. (c)

\[ I = \frac{10}{50} = 0.2 \text{ A} = 200 \text{ mA} \]

22. What is the output voltage \( V_o \) for the circuit shown below assuming an ideal diode?

<table>
<thead>
<tr>
<th>Option</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>(-\frac{18}{5} \text{ V})</td>
</tr>
<tr>
<td>(b)</td>
<td>(\frac{18}{5} \text{ V})</td>
</tr>
<tr>
<td>(c)</td>
<td>(-\frac{13}{5} \text{ V})</td>
</tr>
<tr>
<td>(d)</td>
<td>(\frac{13}{5} \text{ V})</td>
</tr>
</tbody>
</table>

Ans. (a)

\( \because \) Diode is forward bias (short circuit)

So by applying KVL

\[ 3 + 3k\Omega I - 5 + 2k\Omega I + 1 = 0 \]

\[ I = \frac{1}{5k\Omega} = \frac{1}{5} \text{ mA} \]

\[ \therefore \quad V_o = -3 - 3 \times \frac{1}{5} = -\frac{18}{5} \text{ V} \]
23. In a semiconductor diode, cut-in voltage is the voltage
(a) upto which the current is zero
(b) upto which the current is very small
(c) at which the current is 10% of the maximum rated current
(d) at which depletion layer is formed

**Ans. (b)**
It is a definition of cut-in voltage.

---

24. A transistor circuit is shown in the figure. Assume $\beta = 100$, $R_B = 200\, \text{k}\Omega$, $R_C = 1\, \text{k}\Omega$, $V_{CC} = 15\, \text{V}$, $V_{BE\text{ act}} = 0.7\, \text{V}$, $V_{BE\text{ sat}} = 0.8\, \text{V}$ and $V_{CE\text{ sat}} = 0.2\, \text{V}$.

![Transistor Circuit Diagram]

The transistor is operating in
(a) Saturation
(b) Cut-off
(c) Normal active
(d) Reverse active

**Ans. (c)**

$$I_{C\text{ sat}} = \frac{V_{CC} - V_{CE\text{ sat}}}{R_C} = \frac{14.8}{1\, \text{k}\Omega} = 14.8\, \text{mA}$$

$$I_B = \frac{V_{CC} - V_{BE\text{ sat}}}{R_B} = \frac{14.2}{200\, \text{k}\Omega} = 0.071\, \text{mA}$$

$$I_{B\text{ min}} = \frac{I_{C\text{ sat}}}{\beta} = \frac{14.8}{100} = 0.148\, \text{mA}$$

Since $I_B < I_{B\text{ min}}$, BJT is operating in normal active mode.

---

25. The position of the intrinsic Fermi level of an undoped semiconductor ($E_{Fi}$) is given by

(a) $\frac{E_C - E_V}{2} + \frac{kT}{2} \ln\frac{N_V}{N_C}$
(b) $\frac{E_C + E_V}{2} - \frac{kT}{2} \ln\frac{N_V}{N_C}$
(c) $\frac{E_C + E_V}{2} + \frac{kT}{2} \ln\frac{N_V}{N_C}$
(d) $\frac{E_C - E_V}{2} - \frac{kT}{2} \ln\frac{N_V}{N_C}$
Ans. (c)

\[ E_{fj} = \frac{E_C + E_V}{2} \left( \frac{kT}{2} \right) \ln \frac{N_C}{N_V} \quad \text{or} \quad \frac{E_C + E_V}{2} \left( \frac{kT}{2} \right) \ln \frac{N_V}{N_C} \]

26. The stability factor \( S \) in a bipolar junction transistor is

(a) \[ \frac{1 + \beta}{1 - \beta} \left( \frac{dI_B}{dI_C} \right) \]

(b) \[ \left( 1 + \frac{\beta}{1 - \beta} \right) \left( 1 - \left( \frac{dI_B}{dI_C} \right) \right) \]

(c) \[ (1 + \beta) \left( 1 - \beta \left( \frac{dI_B}{dI_C} \right) \right) \]

(d) \[ \frac{\beta - 1}{1 - \beta} \left( \frac{dI_B}{dI_C} \right) \]

Ans. (a)

\[ S = \frac{1 + \beta}{1 - \beta} \frac{dI_B}{dI_C} \]

27. The leakage current in an NPN transistor is due to the flow of

(a) Holes from base to emitter
(b) Electrons from collector to base
(c) Holes from collector to base
(d) Minority carriers from emitter to collector

Ans. (c)

28. In Early effect

(a) Increase in magnitude of Collector voltage increases space charge width at the input junction of a BJT
(b) Increase in magnitude of Emitter-Base voltage increases space charge width of output junction of a BJT
(c) Increase in magnitude of Collector voltage increases space charge width of output junction of a BJT
(d) Decrease in magnitude of Emitter-Base voltage increases space charge width of output junction of a BJT

Ans. (c)

Output junction is C-B junction which is always \( RB \) and by increasing the magnitude of \( RB \) voltage depletion layer width at collector junction increases.

---

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29. The signal \( x(t) = u(t + 2) - 2u(t) + u(t - 2) \) is represented by

(a) \[
\begin{array}{c|c|c|c|c|c}
0 & 1 & 2 & 3 & 4 & \hline \\
1 & 1 & 1 & 1 & 1 & \\
\end{array}
\]

(b) \[
\begin{array}{c|c|c|c|c|c}
0 & 1 & 2 & 3 & 4 & \hline \\
1 & 1 & 1 & 1 & 1 & \\
\end{array}
\]

(c) \[
\begin{array}{c|c|c|c|c|c}
0 & 1 & 2 & 3 & 4 & \hline \\
1 & 1 & 1 & 1 & 1 & \\
\end{array}
\]

(d) \[
\begin{array}{c|c|c|c|c|c}
0 & 1 & 2 & 3 & 4 & \hline \\
1 & 1 & 1 & 1 & 1 & \\
\end{array}
\]

Ans. (b)

Shifts represents instants where change in step will occur and coefficients represent the amount of step change at the shifts given to \( u(t) \).

i.e. \( u(t - (-2)) - 2u(t - 0) + u(t - 2) \)

hence,

\[
\begin{array}{c|c|c|c|c|c}
0 & 1 & 2 & 3 & 4 & \hline \\
1 & 1 & 1 & 1 & 1 & \\
\end{array}
\]

30. The figure shown represents

(a) n-channel MOSFET

(b) Enhanced-mode E-MOSFET

(c) p-Channel MOSFET

(d) J-FET

Ans. (a)

n-channel MOSFET
31. The PMOSFET circuit shown in the figure has $V_{TP} = -1.4 \text{ V}$, $K'_P = 25 \mu\text{A/V}^2$, $L = 2 \mu\text{m}$, $\lambda = 0$. If $I_{DS} = -0.1 \text{ mA}$ and $V_{DS} = -2.4 \text{ V}$ then the width of channel $W$ and $R$ are respectively

(a) 16 $\mu\text{m}$ and 66 $\text{k} \Omega$

(b) 18 $\mu\text{m}$ and 33 $\text{k} \Omega$

(c) 16 $\mu\text{m}$ and 33 $\text{k} \Omega$

(d) 18 $\mu\text{m}$ and 66 $\text{k} \Omega$

Ans. (a)

Since $G$ and $D$ are short, MOSFET is in saturation. Since $\gamma = 0$,

$$I_D = \frac{1}{2} K'_P \frac{W}{L} (V_{GS} - V_T)^2 \quad \text{and} \quad V_{GS} = V_{DS} = -2.4 \text{ V}$$

$$-0.1 \times 10^{-3} = \frac{1}{2} \left(25 \times 10^{-6}\right) \frac{W}{2 \times 10^{-6}} \left[-2.4 - (-1.4)\right]^2$$

$$W = \frac{0.4 \times 10^{-3}}{25} = 16 \mu\text{m}$$

Applying KVL to the circuit

$$0 = I_D R + V_{GS} + 9$$
$$0 = -0.1 \times 10^{-3} (R) - 2.4 + 9$$
$$R = 66 \text{ k} \Omega$$

32. Maximum energy of electrons liberated photoelectrically is

(a) Proportional to light intensity and independent of frequency of the light
(b) Independent of light intensity and, varies linearly with frequency of the light
(c) Proportional to both, light intensity and frequency of the light
(d) Independent of light intensity and inversely proportional to frequency of the light

Ans. (c)

33. The response of a Gaussian random process applied to a stable linear system is

1. A Gaussian random process
2. Not a Gaussian random process
3. Completely specified by its mean and auto-covariance functions

Which of the above statements is/are correct?

(a) 1 only
(b) 2 only
(c) 2 and 3
(d) 1 and 3

Ans. (d)
34. Consider a system, which computes the 'MEDIAN' of signal values in a window of size ‘N’. Such a discrete time system is
   (a) Linear  (b) Non-linear  
   (c) Sometimes linear  (d) Sometimes non-linear

Ans. (b)

If $F$ is function, then it is said to be linear if

$$F(A + B) = F(A) + F(B)$$

So now say there are two sets of numbers.

$A = [2 \ 5 \ 9 \ 6 \ 3]$  
$B = [1 \ 0 \ 4 \ 7 \ 4]$  

mean($A$) = 5  
mean($B$) = 3.2  

mean($A + B$) = 8.2 = mean($A$) + mean($B$)

So you can see that mean is a linear operation and median is not. Now think in terms of signals or images and the same rule applies. In real life you will care about this in image processing only in some particularly.

35. Consider a discrete time system which satisfies the additivity property, i.e., if the output for $u_1[n]$ is $y_1[n]$ and that for $u_2[n]$ is $y_2[n]$, then output for $u_1[n] + u_2[n]$ is $y_1[n] + y_2[n]$. Such a system is
   (a) Linear  (b) Sometimes linear  
   (c) Non-linear  (d) Sometimes non-linear

Ans. (b, d)

- Linearity is combination of homogeneity principle and additivity principle.
- When system verifies additivity principle it still need not necessarily verify homogeneity.
- Hence, system can be sometimes linear [when homogeneity principle is also verified] and sometimes non linear [when homogeneity principle is not verified].

36. Consider an ideal low pass filter. Such a discrete-time system is
   (a) always realizable physically  (b) never realizable physically  
   (c) a non linear system  (d) a linear, causal system

Ans. (b)

Ideal LPF magnitude response

$$|H(\omega)| = e^{j2\pi c(\omega)}$$

Gate pulse of width $2\omega_c$
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\[ H(\omega) = \left| H(\omega) \right| e^{j\angle H(\omega)} \]

\[ \tau \cdot \text{Sa}\left( t - \frac{T}{2} \right) \quad \leftrightarrow \quad 2\pi \epsilon(\omega) \]

\[ \angle H(\omega) \rightarrow (\text{linear}) = -\omega t_0 \text{ for distortionless transmission} \]

∴ \[ \frac{\omega_0}{\pi} S_2(\omega_0 t) \leftrightarrow G_2(\omega_0 e^{-j\omega t_0}) \]

\[ H(\omega) = G_2(\omega_0)e^{-j\omega t_0} \]

\[ h(t) = \frac{\omega_0}{\pi} S_2(\omega_0 (t - t_0)) \]

And as \( h(t) \neq 0 \); \( t < 0 \), system is non-causal meaning never physically realizable.

**37.** The result of \( h(2t) \ast \delta(t_0 - 10) \) (\( \ast \) denotes convolution and \( \delta(\cdot) \) denotes the Dirac delta function) is

(a) \( h(2t_0 - 2t) \)

(b) \( h(2t_0 - 2t) \)

(c) \( h(-2t - 2t_0) \)

(d) \( h(2t + 2t_0) \)

**Ans. (a)**

According to the convolution property

\[ x(t) \ast \delta(t - t_0) = x(t - t_0) \]

Hence, \( h(2t) \ast \delta(t - t_0) = h(2(t - t_0)) = h(2t - 2t_0) \)

**38.** A ray of light incident on a glass slab (of refractive index 1.5) with an angle \( \frac{\pi}{4} \), then the value of sine of angle of refraction is

(a) \( \frac{1}{\sqrt{2}} \)

(b) \( \frac{3}{\sqrt{2}} \)

(c) \( \frac{\sqrt{2}}{3} \)

(d) \( \sqrt{2} \)
Ans. (c)

\[ n_1 \sin \theta_1 = n_2 \sin \theta_2 \]

\[ \sin 45^\circ = 1.5 \sin \theta_2 \]

\[ \frac{1}{\sqrt{2}} = 1.5 \times \sin \theta_2 \]

\[ \sin \theta_2 = \frac{\sqrt{2}}{3} \]

39. The complex exponential power form of Fourier series of \( x(t) \) is

\[ x(t) = \sum_{k=-\infty}^{\infty} a_k e^{j \frac{2\pi}{T_0} kt} \]

if \( x(t) = \sum_{b=-\infty}^{\infty} \delta(t-b) \), then the value of \( a_k \) is

(a) \( 1 - (-1)^k \)  
(b) \( 1 + (-1)^k \)  
(c) \( 1 \)  
(d) \( -1 \)

Ans. (c)

\[ x(t) = \sum_{b=-\infty}^{\infty} \delta(t-b) \]

\[ \cdots \delta(t+2) + \delta(t+1) + \delta(t) + \delta(t-1) + \delta(t-2) + \cdots \]

\[ a_k = \frac{1}{T_0} \int_{-T_0/2}^{T_0/2} x(t) e^{-j \frac{2\pi}{T_0} kt} \, dt \]

\[ = \frac{1}{T_0} \int_{-1/2}^{1/2} \delta(t) e^{-j \frac{2\pi}{T_0} kt} \, dt \]

\[ = 1 \]
40. Laplace transform of the function $v(t)$ shown in the figure is

\[ v(t) = \begin{cases} 1 & t \geq 0 \\ 0 & t < 0 \end{cases} \]

(a) $s^2[1 - e^s]$  
(b) $s^2[1 - e^{-s}]$  
(c) $\frac{1}{s^2}[1 - e^s]$  
(d) $\frac{1}{s^2}[1 - e^{-s}]$  

Ans. (d)

From the figure, $v(t) = r(t) - r(t - 1)$

Apply LT, $V(s) = \frac{1}{s^2} - \frac{1}{s^2}e^{-s}$

\[ = \frac{1}{s^2}[1 - e^{-s}] \]

\[ \therefore r(t) \longleftrightarrow \frac{1}{s^2} \]

\[ \therefore \text{Time shifting property} \quad \delta(t - t_o) \longleftrightarrow X(s)e^{-st_o} \]

41. In a discrete-time complex exponential sequence of frequency $\omega_0 = 1$, the sequence is

1. Periodic with period $\frac{2\pi}{\omega_0}$
2. Non periodic
3. Periodic for some value of period $N$

Which of the above statements is/are correct?

(a) 1 only  
(b) 2 only  
(c) 3 only  
(d) 1 and 3

Ans. (b)

Given that, $\omega_0 = 1$

For discrete time exponential to be periodic $C = \frac{2\pi}{\omega_0}$ (should be rational)

In the present case $\frac{2\pi}{1} \Rightarrow \text{Non-periodic.}$

42. Consider the following transforms:

1. Fourier transform  
2. Laplace transform

Which of the above transforms is/are used in signal processing?

(a) 1 only  
(b) 2 only  
(c) Both 1 and 2  
(d) Neither 1 nor 2
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**MADE EASY selections in ESE-2015:** 82% of Total Vacancies

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</table>

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Ans. **(a)**

- Laplace transform used for stability verifications, transient analysis and system synthesis.
- In signal processing (which basically means filtering) Fourier transform are used, as filtering requires information purely in terms of frequency.

---

43. The varactor diode has a voltage-dependent:
1. Resistance 2. Capacitance 3. Inductance
Which of the above is/are correct?
(a) 1 only  (b) 2 only  (c) 3 only  (d) 1 and 3

**Ans. (b)**

Varactor diode is also called variable capacitance diode by varying the the RB voltage, we can alternate the junction capacitance $C_T$.

---

44. The impulse response for the discrete-time system

$$y[n] = 0.24 (x[n] + x[n - 1] + x[n - 2] + x[n - 3])$$

is given by

(a) 0 for $0 \leq n \leq 3$ and 0.24 otherwise
(b) 0.24 for $0 \leq n \leq 3$ and 0 otherwise
(c) 0.24 for $n = 0$ to $n = \infty$
(d) 0 for $n = 0$ to $n = \infty$

**Ans. (b)**

When input $x[n] = \delta[n]$, response

$$y[n] = h[n] \rightarrow \text{unit impulse response}$$

$$h[n] = 0.24[\delta[n] + \delta[n - 1] + \delta[n - 2] + \delta[n - 3]]$$

i.e. $h[n] = 0.24 \quad 0 \leq n \leq 3$

$= 0 \quad $otherwise

---

45. The product of emitter efficiency ($\gamma$) and transport factor ($\beta^*$) for a BJT is equal to

(a) Small signal current gain  (b) High frequency current gain
(c) Power loss in the BJT  (d) Large-signal current gain

**Ans. (d)**

For a BJT, $\alpha = \beta^* \gamma$

where $\alpha$ is is large signal current gain
46. Consider a two-sided discrete-time signal (neither left sided, nor right sided). The region of convergence (ROC) of the z-transform of the sequence is
1. All region of z-plane outside a unit circle (in z-plane)
2. All region of z-plane inside a unit circle (in z-plane)
3. Ring in z-plane
Which of the above is/are correct?
(a) 1 only
(b) 2 only
(c) 3 only
(d) 1 and 3

Ans. (c)
From the properties of ROC of z-transform, for a two sided sequences the ROC of its z-transform is in the form of circular strip or annular strip i.e., in the form of ring.

47. When is a function \( f(n) \) said to be leftsided?
(a) \( f(n) = 0 \) for \( n < 0 \)
(b) \( f(n) < 0 \) for \( n > 0 \)
(c) \( f(n) = 0 \) for \( n > n_0 \)
(d) \( f(n) = \infty \) for \( n < n_0 \)

\( n_0 \rightarrow \) Positive or negative integer

Ans. (c)
A signal having a non-zero value towards left of a finite value of time till \( t = -\infty \) are called left sided signal.
i.e., for example

\[
f(n) = u(-n + n_0)
\]

\[
\ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots 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\]

Hence, \( f(n) = 0 \), for \( n > n_0 \)

48. Z-transform deals with discrete time systems for their
1. Transient behaviour
2. Steady-state behavior
Which of the above behaviours is/are correct?
(a) 1 only
(b) 2 only
(c) Both 1 and 2
(d) Neither 1 nor 2

Ans. (c)
Using the unilateral transforms [both Laplace and z-transform] the analysis of continuous time and discrete time systems can be analysed both for transient [using time differentiation property (Laplace transform), using time shifting property (z-transform)] and steady state responses [using final value theorem].
49. The response of a linear, time-invariant, discrete-time system to a unit step input $u[n]$ is $\delta[n]$. The system response to a ramp input $n \cdot u[n]$ would be
(a) $\delta[n - 1]$
(b) $u[n - 1]$
(c) $n \cdot \delta[n - 1]$
(d) $n \cdot u[n - 1]$

Ans. (b)
From LTI system, response, for $u[n] \rightarrow \delta[n]$, for ramp input $nu[n] = r[n]$
i.e., $u[n - 1] + u[n - 2] + \cdots = \delta[n - 1] + \delta[n - 2] + \cdots$
Hence, $u[n - 1]$.

50. Consider a discrete-random variable $z$ assuming finitely many values. The cumulative
distribution function, $F_z(z)$ has the following properties:

1. $\int_{-\infty}^{\infty} F_z(z) \, dz = 1$
2. $F_z(z)$ is non-decreasing with finitely many jump-discontinuities
3. $F_z(z)$ is negative and non-decreasing
Which of the above properties is/are correct?
(a) 1 only (b) 2 only (c) 3 only (d) 2 and 3

Ans. (b)

51. Consider a random process given by: $x(t) = Acos(2\pi ft + \theta)$, where $A$ is a Rayleigh
distributed random variable and $\theta$ is distributed in $[0, 2\pi]$. $A$ and $\theta$ are independent.
For any time $t$, the probability density function (PDF) of $x(t)$ is
(a) Gaussian (b) Rayleigh (c) Rician (d) Uniform in $[-A, A]$

Ans. (a)

52. Poisson’s equation is derived with the following assumption about the medium. The
medium is
(a) Non-homogeneous and isotropic (b) Non-homogeneous and non-isotropic
(c) Homogeneous and non-isotropic (d) Homogeneous and isotropic

Ans. (d)

53. The state space representation of a linear time invariant system is

$$X(t) = A X(t) + Bu(t) \quad Y(t) = C X(t)$$

What is the transfer function $H(s)$ of the system?
(a) $C(sI - A)^{-1} B$
(b) $B(sI - A)^{-1} C$
(c) $C(sI - A) B$
(d) $B(sI - A) C$

Ans. (d)
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Ans. (a)

\[ Y(s) = CX(s) \]

\[ sX(s) = AX(s) + BU(s) \quad \Rightarrow \quad X(s)[s - A] = BU(s) \]

\[ X(s) = (sl - A)^{-1} BU(s) \]

\[ \frac{Y(s)}{U(s)} = C(sl - A)^{-1} B \]

54. \( x(t) = \frac{1}{T_0} + \sum_{k=1}^{N} \frac{2}{T_0} \cos{k\omega_0}t \) is the combined trigonometric form of Fourier series for

(a) Half rectified wave (b) Saw-tooth wave (c) Rectangular wave (d) Impulse train

Ans. (d)

Given that, \( x(t) = \frac{1}{T_0} + \sum_{k=1}^{N} \frac{2}{T_0} \cos{k\omega_0}t \)

\[ a_0 = \frac{1}{T_0}, \quad a_k = \frac{2}{T_0} \]

As the Fourier series coefficient \( a_k \) is independent of ‘K’ signal cannot be sawtooth, half rectified (or) rectangular. Hence, impulse train.

(or)

The otherway is evaluating Fourier series coefficients are verifying.

55. A signal \( x_n \) is given by \( x_0 = 3, x_1 = 2, x_2 = 5, x_3 = 1, x_4 = 1, x_5 = 2, x_7 = 2, x_8 = 4 \), where the subscript ‘n’ denotes time. The peak value of the auto correlation of \( x_{2n - 11} \) is

(a) 0 (b) 10 (c) 54 (d) 64

Ans. (b)

56. A system has impulse response \( h[n] = \cos(n)u[n] \). The system is

(a) Causal and stable (b) Non causal and stable (c) Non causal and not stable (d) Causal and not stable

Ans. (d)

\( h[n] = \cos(n)u[n] \)

- Multiplication by \( u[n] \) ensures,
  \[ h[n] = 0, \quad n < 0 \] Hence, causal
- \( h[n] \) must be absolutely summable
\[
\left(\text{if } \sum_{n=\infty}^{\infty} |h[n]| < \infty\right) \text{ which is not verified by above } h[n].
\]
So it is not stable.

57. If the three resistors in a delta network are all equal in values i.e. \( R_{\text{DELTA}} \), then the value of the resultant resistors in each branch of the equivalent star network i.e. \( R_{\text{STAR}} \) will be equal to
(a) \( \frac{R_{\text{DELTA}}}{3} \)  
(b) \( \frac{R_{\text{DELTA}}}{2} \)  
(c) \( 2R_{\text{DELTA}} \)  
(d) \( R_{\text{DELTA}} \)

**Ans.** (a)
Delta to star \( \Rightarrow \) Resistance decreases by 3 times.

58. Loop-voltage equations of a passive circuit are given by
\[
\begin{bmatrix}
Z_{11} & Z_{12} & Z_{13} \\
Z_{21} & Z_{22} & Z_{23} \\
Z_{31} & Z_{32} & Z_{33}
\end{bmatrix}
\begin{bmatrix}
I_1 \\
I_2 \\
I_3
\end{bmatrix}
=
\begin{bmatrix}
V_1 \\
V_2 \\
V_3
\end{bmatrix}
\]
1. \( Z_{ij} = Z_{ji}, \; i, j = 1, 2, 3 \)
2. \( Z_{ii} > 0, \; i = 1, 2, 3 \)
3. \( \Delta Z \leq 0 \)
Which of the above relations are correct?
(a) 1 and 2 only  
(b) 1 and 3 only  
(c) 2 and 3 only  
(d) 1, 2 and 3

**Ans.** (a)

59. A function \( c(t) \) satisfies the differential equation \( c(t) + c(t) = \delta(t) \). For zero initial condition \( c(t) \) can be represented by
(a) \( e^{-t} \)  
(b) \( e^{t} \)  
(c) \( e^{t} u(t) \)  
(d) \( e^{-t} u(t) \)
where \( u(t) \) is a unit step function

**Ans.** (d)
\[
\frac{dc}{dt} + c(t) = \delta(t)
\]
\[
sC(s) + C(s) = 1
\]
\[
C(s) = \frac{1}{s+1}
\]
\[
c(t) = e^{-t} u(t)
\]
60. For the network shown, Thevenin's equivalent voltage source and resistance are, respectively

(a) 1 mV and 10 Ω  
(b) 1 V and 1 kΩ  
(c) 1 mV and 1 kΩ  
(d) 1 V and 10 Ω

Ans. (d)

Case-I ($V_{Th}$):

\[ I_1 + 99I_1 = 0 \] 
\[ I_1 = \frac{1-V_{Th}}{1 \times 10^3} \]

From equation (i),

\[ 100 I_1 = 0 \]
\[ 100 \left( \frac{1-V_{Th}}{1 \times 10^3} \right) = 0 \]
\[ 100 - 100 V_{Th} = 0 \]
\[ V_{Th} = 1 \]

Case-2 ($R_{Th}$):

\[ I_1 + 99I_1 + 1 = 0 \]
\[ I_1 = \frac{-V_A}{1 \times 10^3} \]

From equation (iii),

\[ 100 I_1 + 1 = 0 \]
\[ \left( \frac{-V_A}{1000} \right) + 1 = 0 \]
\[ -V_A + 10 = 0 \]
\[ V_A = 10 \]
\[ R_{Th} = \frac{V_A}{I_s} = \frac{10}{1} = 10 \Omega \]
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61. In the circuit shown, if the power consumed by the 5 Ω resistor is 10 W, then the power factor of the circuit is

\[ v(t) = 50 \cos \omega t \]

(a) 0.8  (b) 0.6  
(c) 0.4  (d) 0.2

**Ans. (b)**

\[ P_5 = i^2 R_5 \]
\[ 10 = i^2 \times 5 \]
\[ i = \sqrt{2} \]
\[ Z = \frac{V}{I} = \frac{50/\sqrt{2}}{\sqrt{2}} = 25 \]
\[ \text{PF} = \cos \theta = \frac{R_{eq}}{Z} = \frac{5 + 10}{25} \]
\[ \cos \theta = 0.6 \]

62. For the circuit shown, if the power consumed by 5 Ω resistor is 10 W, then

1. \[ |I| = \sqrt{2} \text{ A} \]
2. Total impedance = 5 Ω
3. Power factor 0.866

Which of the above are correct?

(a) 1 and 3 only  
(b) 1 and 2 only  
(c) 2 and 3 only  
(d) 1, 2 and 3

**Ans. (a)**

\[ P_5 = i^2 R_5 \]
\[ 10 = i^2 \times 5 \]
\[ i = \sqrt{2} \]
\[ Z = \sqrt{R^2 + X_L^2} = \sqrt{15^2 + \left(\frac{15}{\sqrt{3}}\right)^2} = \sqrt{300} \]
\[ \cos \theta = \frac{R_{eq}}{Z} = \frac{5 + 10}{\sqrt{300}} = 0.866 \]
63. For a given fixed tree of a network, the following form an independent set:
1. Branch currents
2. Link voltages
Which of the above is/are correct?
(a) 1 only
(b) 2 only
(c) Both 1 and 2
(d) Neither 1 nor 2

Ans. (d)
1. In Tie-set, link current form independent set.
2. In cut-set, branch voltage form independent set.

64. For the network graph, the number of trees \( P \) and the number of cut-sets \( Q \) are respectively:

(a) 4 and 2
(b) 6 and 2
(c) 4 and 6
(d) 2 and 6

Ans. (c)
65. For which one of the following measurements a thermistor can be used?
(a) Velocity (b) Humidity (c) Displacement (d) Percent of CO₂ in air
Ans. (a)

66. According to network graphs, the network with
1. Only two odd vertices is traversable
2. No odd vertices is traversable
3. Two or more than two odd vertices are traversable
Which of the above statements is/are correct?
(a) 1 only (b) 2 only (c) 3 only (d) 1 and 2
Ans. (d)

A network graph is traversable only if the number of vertices with odd degree in network graph is exactly 2 (or) 0.

67. For any lumped network, for any cut sets and at any instant of time the algebraic sum of all branch currents traversing the cut-set branches is always:
(a) One (b) Zero (c) Infinity (d) Greater than zero, but less than one
Ans. (b)

68. Which one of the following statements concerning Tellegen’s theorem is correct?
(a) It is useful in determining the effects in all parts of a linear four-terminal network
(b) It is applicable for any lumped network having elements which are linear or nonlinear, active or passive, time varying or time-invariant, and may contain independent or dependent sources
(c) It can be applied to a branch, which is not coupled to other branches in a network
(d) It states that the sum of powers taken by all elements of a circuit within constraints imposed by KCL and KVL is non-zero
Ans. (b)

69. The open circuit input impedance of a 2-port network is

\[
\begin{align*}
\frac{A}{\Omega} & \quad \frac{B}{\Omega} \\
\frac{C}{\Omega} & \quad \frac{D}{\Omega}
\end{align*}
\]
(a) \( \frac{A}{C} \) (b) \( \frac{B}{D} \) (c) \( \frac{D}{C} \) (d) \( \frac{A}{B} \)
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Ans. (a)

\[ Z_{11} = \frac{V_1}{I_1} \bigg|_{I_2 = 0} = \frac{AV_2 - BI_2}{CV_2 - DI_2} \bigg|_{I_2 = 0} = \frac{A}{C} \]

---

70. Consider the following statements
1. Two identical 2\textsuperscript{nd} order Butterworth LP filters when connected in cascade will make a 4\textsuperscript{th} order Butterworth LP filter.
2. A high pass 2\textsuperscript{nd} order filter will exhibit a peak if \( Q \) exceeds certain value.
3. A band pass filter cannot be of order one.
4. A network consists of an amplifier of real gain \( A \) and a \( \beta \) network in cascade with each other. The network will generate sinusoidal oscillations if the \( \beta \) network is a first order LP filter.

Which of the above statements are correct?
(a) 1 and 2 (b) 2 and 3 (c) 3 and 4 (d) 1 and 4

Ans. (b)

---

71. The lowest and the highest critical frequencies of RC driving point admittance are, respectively :
(a) a zero and a pole (b) a pole and a zero (c) a zero and a zero (d) a pole and a pole

Ans. (a)

---

72. The poles and zeros of a voltage function \( v(t) \) are : zero at the origin and simple poles at \(-1, -3\) and the scale factor is 5. The contribution of the pole at \(-3\) to \( v(t) \) is
(a) \( 2.5 e^{-3t} \) (b) \( 7.5 e^{+3t} \) (c) \( 2.5 e^{+3t} \) (d) \( 7.5 e^{-3t} \)

Ans. (b)

\[ V(s) = \frac{5s}{(s+1)(s+3)} = A \frac{s+1}{s+3} + B \]

\[ V(s) = \frac{-5/2}{s+1} + \frac{15/2}{s+3} \]

\[ \downarrow \]

\[ 7.5e^{-3t} \]
73. The driving point impedance of the circuit shown is given by \( Z(s) = \frac{0.2s}{s^2 + 0.1s + 2} \).

![Circuit Diagram]

The component values \( R, L \) and \( C \) are respectively
(a) 0.5 \( \Omega \), 1 H and 0.1 F   (b) 2 \( \Omega \), 5 H and 5 F
(c) 0.5 \( \Omega \), 0.1 H and 0.1 F   (d) 2 \( \Omega \), 0.1 H and 5 F

Ans. (d)

\[
Z(s) = \frac{0.2s}{s^2 + 0.1s + 2} \\
Y(s) = \frac{s^2 + 0.1s + 2}{0.2s} \\
Y(s) = \frac{s + 1}{0.2} + \frac{2}{0.2s} \\
Y(s) = 5s + \frac{1}{2} + \frac{10}{s} \\
B_c = sC \quad G = 0.5 \quad B_L = \frac{1}{Ls} \\
C = 5 \quad R = 2 \quad L = \frac{1}{10} = 0.1
\]

74. Consider the following driving point impedances which are to be realized using passive elements:

1. \( \frac{s + 2}{s^2(s + 5)} \)
2. \( \frac{s^2 + 3}{s^2(s + 5)} \)

Which of the above is/are realizable?
(a) 1 only   (b) 2 only
(c) Both 1 and 2   (d) Neither 1 nor 2

Ans. (d)

75. A reactance function in the first Foster form has poles at \( \omega = 0 \) and \( \omega = \infty \). The black-box (B.B.) in the network contains:
Consider the following statements:
1. The magnetic field at the centre of a circular coil of a wire carrying current is inversely proportional to the radius of the coil.
2. Lifting power of a magnet is proportional to square of magnetic flux density.
3. A static electric field is conservative (irrotational).
4. If the divergence of a vector ‘A’ is zero, then vector ‘A’ can be expressed as Curl of a vector F.

Which of the above statements are correct?
(a) 1, 2 and 3 only  (b) 3 and 4 only  
(c) 1, 2 and 4 only  (d) 1, 2, 3 and 4

Ans. (d)
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78. Consider the following sources:
- 1. A permanent magnet
- 2. A charged disc rotating at uniform speed
- 3. An accelerated charge
- 4. An electric field which changes linearly with time

Which of the above are the sources of steady magnetic field?
(a) 1, 2 and 3 only  (b) 3 and 4 only  (c) 1, 2 and 4 only  (d) 1, 2, 3 and 4

Ans. (c)

79. A charge Q is enclosed by a Gaussian spherical surface of radius R. If R is doubled then the outward flux is
(a) Doubled  (b) Increased four times  (c) Reduced to a quarter  (d) Remains unaltered

Ans. (d)

80. Divergence of a vector \( \text{div} \ D \) in the cylindrical coordinate system is
(a) \( \frac{1}{\rho} \frac{\partial}{\partial \rho} (\rho D_{\rho}) + \frac{1}{\rho} \frac{\partial D_{\phi}}{\partial \phi} + \frac{\partial D_z}{\partial z} \)
(b) \( \frac{1}{\rho} \frac{\partial}{\partial \rho} (\rho D_{\rho}) + \frac{1}{\rho} \frac{\partial (\rho D_{\phi})}{\partial \phi} + \frac{I}{z} \frac{\partial (ZD_z)}{\partial z} \)
(c) \( \frac{1}{\rho} \frac{\partial}{\partial \rho} (\rho D_{\rho}) + \frac{I}{\rho} \frac{\partial D_{\phi}}{\partial \phi} + \frac{\partial D_z}{\partial z} \)
(d) \( \frac{\partial D_{\rho}}{\partial \rho} + \frac{\partial D_{\phi}}{\partial \phi} + \frac{\partial D_z}{\partial z} \)

Ans. (c)

81. What is the value of work required to move a + 8 nC charge from infinity to a point P which is at 2 m distance from a point charge \( Q = + 5 \mu \text{C} \)?
(a) 180 \( \mu \text{J} \)  (b) 180 \( \mu \text{J} \)  (c) 18 \( \mu \text{J} \)  (d) 18 nJ

Ans. (a)

Work done = \( \omega = -Q \int_{\text{initial}}^{\text{final}} E \cdot d\vec{l} = Q \left[ -\int_{\infty}^{\text{final}} \vec{E} \cdot d\vec{l} \right] = Q V \)

Potential at 2 m distance from a point charge \( Q \) at the origin is
\( V = \frac{Q'}{4\pi \epsilon_0 r} = \frac{5 \times 10^{-6}}{2} \left( 9 \times 10^9 \right) \)
\( W = QV = 8 \times 10^{-3} \left( 5 \times 10^{-6} \right) \left( 9 \times 10^9 \right) = 4 \times 5 \times 9 \times 10^{-6} = 180 \mu \text{J} \)
82. An electrostatic force between two point charges increases when they are
(a) More apart and dielectric constant of the medium between them decreases
(b) Less apart and dielectric constant of the medium between them decreases
(c) More apart and dielectric constant of the medium between them increases
(d) Less apart and dielectric constant of the medium between them increases

Ans. (b)

Force between two point charges \( Q_1 \) and \( Q_2 \) is

\[
F = \frac{Q_1 Q_2}{4\pi \varepsilon d^2}
\]

If \( d, \varepsilon \) both decreases than \( F \) increases.

83. A plane \( Y = 2 \) carries infinite sheet of charge 6 nC/m². If medium is free space then
force on a point charge of 10 mC located at the origin is

(a) \( -1080 \pi \mathbb{F}_y \) N
(b) \( -108 \pi \mathbb{F}_y \) N
(c) \( -10.8 \pi \mathbb{F}_y \) N
(d) \( -1.08 \pi \mathbb{F}_y \) N

Ans. (d)

Electric field at origin due to \( P_s = \frac{6 \text{ nC}}{m^2} \) infinite sheet charge on \( y = 2 \) surface is

\[
\vec{E} = \frac{P_s}{2\varepsilon_0} \mathbb{F}_N = \frac{6 \times 10^{-9}}{2 \frac{1}{36\pi}} \mathbb{F}_y = 3 \times 36\pi \mathbb{F}_y = 108\pi \mathbb{F}_y
\]

Force m 10 mC charge = \( \vec{F} = QE \)

\[
\vec{F} = 10 \times 10^{-3} \left[ 3 \times 36\pi (-\mathbb{F}_y) \right] = 1.08\pi (-\mathbb{F}_y)
\]

84. The potential at the centroid of an equilateral triangle of side \( r\sqrt{3} \) due to three equal positive point charges each of value \( q \) and placed at the vertices of the triangle would be

(a) \( \frac{q}{2\pi \varepsilon_0 r} \)
(b) \( \frac{\sqrt{3}q}{8\pi \varepsilon_0 r} \)
(c) \( \frac{3q}{4\pi \varepsilon_0 r} \)
(d) zero
Ans. (c)
If \( a \) is the side of the equilateral triangle than potential at the centre due to 3 point charges each having ‘\( q \)’ charge at corners is

\[
V = \frac{3\sqrt{3} q}{4\pi \varepsilon_0 a}
\]

given side of equilateral triangle = \( a = r\sqrt{3} \)

\[
V = \frac{3\sqrt{3} q}{4\pi \varepsilon_0 r\sqrt{3}} = \frac{3q}{4\pi \varepsilon_0 r}
\]

85. The point form of the relation connecting vector magnetic potential \( A \) and current density \( J \) is

(a) \( \nabla \times A = J + \frac{\partial D}{\partial t} \)  
(b) \( A = \int \frac{\mu_0 J}{4\pi \varepsilon R} \ dv \)

(c) \( \nabla^2 A = -\mu_0 J \)  
(d) \( \frac{\partial A}{\partial t} = -\frac{J}{\sigma} \)

Ans. (c)

86. In the region \( Z < 0, \varepsilon_1 = 2, E_1 = 3\bar{a}_x + 4\bar{a}_y - 2\bar{a}_z \) V/m. For region \( Z > 0, \varepsilon_2 = 6.5, E_2 \) is

(a) \(-3\bar{a}_x + 4\bar{a}_y + \frac{6.5}{4}\bar{a}_z \) V/m  
(b) \(-3\bar{a}_x + 4\bar{a}_y + \frac{4}{6.5}\bar{a}_z \) V/m

(c) \(-3\bar{a}_x + 4\bar{a}_y - \frac{6.5}{4}\bar{a}_z \) V/m  
(d) \(-3\bar{a}_x + 4\bar{a}_y - \frac{4}{6.5}\bar{a}_z \) V/m

Ans. (d)

For \( z = 0 \) boundary \( \hat{a}_z \) component of the vector is normal.

\[
\bar{E}_1 = -3\hat{a}_x + 4\hat{a}_y - 2\hat{a}_z \\
\bar{E}_t_1 = -3\hat{a}_x + 4\hat{a}_y ; \bar{E}_{N1} = -2\hat{a}_z
\]

First boundary condition \( \Rightarrow \bar{E}_{t_1} = \bar{E}_{t_2} \)

\[
\bar{E}_{t_2} = -3\hat{a}_x + 4\hat{a}_y
\]

Second boundary condition \( \Rightarrow \bar{D}_{N1} = \bar{D}_{N2} \)
INTERVIEW GUIDANCE PROGRAM FOR ESE-2016

Soon after the announcement of written results

Interview is the most crucial stage which decides the selection or rejection of the candidate. As per the analysis, the ratio of finally selected candidates to written qualified candidates is 1:2.5 Obtaining 120 marks in engineering services interview is considered as impressive score, and over the years we have noticed that only few candidates managed to score above 120 marks. In previous engineering services examinations, numerous candidates from MADE EASY secured more than 140 marks which is an extraordinary achievement of qualitative training and sincere efforts of the aspirants.

MADE EASY will conduct

MADE EASY’s Top 10 Performers of Personality Test in all 4 Streams

Civil Engineering

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Electrical Engineering

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Electronics & Telecommunication Engg.

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\[ \varepsilon_1 E_{N1}^2 = \varepsilon_2 E_{N2}^2 \]
\[ \begin{align*}
E_{N2}^2 &= \frac{\varepsilon_1}{\varepsilon_2} E_{N1}^2 + \frac{2\varepsilon_0}{6.5} (-2a_z) \\
E^2 &= \frac{4}{6.5} a_z \\
E_2 &= E_{N1}^2 + E_{N2}^2 = -3\varepsilon_x + 4\varepsilon_y - \frac{4}{6.5} \varepsilon_z \text{ V/m}
\end{align*} \]

87. Consider the following statements regarding a conductor and free space boundary
1. No charge and no electric field can exist at any point within the interior of a conductor
2. Charge may appear on the surface of a conductor
Which of the above statements are correct?
(a) 1 only  
(b) 2 only  
(c) Both 1 and 2  
(d) Neither 1 nor 2  

Ans. (c)

88. A sphere of homogeneous linear dielectric material of dielectric constant \( \geq 1 \) is placed in a uniform electric field \( E_0 \), then the electric field \( E \) that exists inside the sphere is
(a) Uniform and \( E < E_0 \)  
(b) Uniform and \( E \geq E_0 \)  
(c) Varies but \( E < E_0 \) always  
(d) Varies but \( E > E_0 \) always

Ans. (c)

89. Which of the following Maxwell’s equations represents Ampere’s law with correction made by Maxwell?
(a) \( \nabla \cdot E = \frac{\rho}{\varepsilon_0} \)  
(b) \( \nabla \cdot B = 0 \)  
(c) \( \nabla \times E = \frac{\partial B}{\partial t} \)  
(d) \( \nabla \times B = \mu_0 J + \mu_0 \varepsilon_0 \frac{\partial E}{\partial t} \)

Ans. (d)

90. Precision is composed of two characteristics, one is the number of significant figures to which a measurement may be made, the other is
(a) Conformity  
(b) Meter error  
(c) Inertia effects  
(d) Noise

Ans. (a)
91. If phasors \( P_1 = 3 + j4 \) and \( P_2 = 6 - j8 \), then \( |P_1 - P_2| \) is
   (a) 5 \hspace{1cm} (b) \( \sqrt{53} \)
   (c) \( \sqrt{73} \) \hspace{1cm} (d) \( \sqrt{153} \)

   **Ans. (d)**

\[
|P_1 - P_2| = \sqrt{3^2 + 12^2} = \sqrt{9 + 144} = \sqrt{153}
\]

92. A plane wave in free space has a magnetic field intensity of 0.2 A/m in the Y-direction. The wave is propagating in the Z-direction with a frequency of 3 GHz. The wavelength and amplitude of the electric field intensity are, respectively:
   (a) 0.05 m and 75 V/m \hspace{1cm} (b) 0.10 m and 75 V/m
   (c) 0.05 m and 150 V/m \hspace{1cm} (d) 0.10 m and 150 V/m

   **Ans. (b)**

\[
\frac{\mu_0}{H} = 0.2 \text{ A/m} \quad \text{f = 3 GHz}
\]
\[
\lambda = \frac{c}{f} = \frac{3 \times 10^8}{3 \times 10^9} = 0.1 \text{ m}
\]
\[
\frac{E}{H} = 120\pi \text{ for free space}
\]
\[
E = 120\pi (H) \Rightarrow E = 120\pi (0.2) = 24\pi = 75 \text{ V/m}
\]

93. For energy propagation in a lossless transmission line, the characteristic impedance of the line is expressed in ohms as below (where notations have usual meanings).

   (a) \( \sqrt{LC} \) \hspace{1cm} (b) \( \frac{L}{\sqrt{C}} \)
   (c) \( \sqrt{\frac{C}{L}} \) \hspace{1cm} (d) \( \frac{R + j\omega L}{\sqrt{G - j\omega L}} \)

   **Ans. (b)**

94. A quarter wavelength transformer is used to match a load of 200 \( \Omega \) to a line with input impedance of 50 \( \Omega \). The characteristic impedance of the transformer would be
   (a) 40 \( \Omega \) \hspace{1cm} (b) 100 \( \Omega \)
   (c) 400 \( \Omega \) \hspace{1cm} (d) 1000 \( \Omega \)

   **Ans. (b)**

\[
Z_0 = \sqrt{(50)(200)} = 100 \Omega
\]
For a lossless transmission line \( L = 0.35 \, \mu \text{H/m}, \, C = 90 \, \text{pF/m} \) and frequency = 500 MHz.
Then the magnitude of propagation constant is
(a) 14.48 \hspace{1cm} (b) 17.63
(c) 19.59 \hspace{1cm} (d) 21.20

Ans. \hspace{0.5cm} (b)

For lossless line,
\[
r = j\omega \sqrt{LC}
\]
\[
|r| = \omega \sqrt{LC} = 2\pi \sqrt{LC}
\]
\[
= 2\pi(500 \times 10^6) \sqrt{0.35 \times 10^{-6} \times 90 \times 10^{-12}}
\]
\[
= 176.32 \times 10^{-1} = 17.63
\]

If an antenna has a main beam with both half-power beam widths equal to 20°, its
directivity (\( D \)) is nearly:
(a) 90.6 \hspace{1cm} (b) 102.5
(c) 205 \hspace{1cm} (d) 226

Ans. \hspace{0.5cm} (b)

\[
\theta_{\text{HP}} = 20^\circ
\]
\[
D = \text{Directivity} = \frac{41253}{(\theta_{\text{HP}})^2} = \frac{4153}{(20)^2} = 103.13
\]

Nearest option is (b).

An instrument always extracts some energy from the measured medium. Thus the
measured quantity is always disturbed by the act of measurement, which makes a perfect
measurement theoretically impossible and it is due to:
(a) Skin-effect \hspace{1cm} (b) Inductive effect
(c) Loading effect \hspace{1cm} (d) Lorenz effect

Ans. \hspace{0.5cm} (c)

The characteristic impedance \( \eta_0 \) of a free space is:
(a) \( \frac{\mu_0}{\varepsilon_0} \) \hspace{1cm} (b) \( \sqrt{\frac{\mu_0}{\varepsilon_0}} \)
(c) \( \sqrt{\mu_0 \varepsilon_0} \) \hspace{1cm} (d) \( \mu_0 \varepsilon_0 \)

Ans. \hspace{0.5cm} (b)

\[
\eta_0 = \sqrt{\frac{\mu_0}{\varepsilon_0}} = 120\pi
\]
99. A $3\frac{1}{2}$ digit voltmeter has an accuracy specification of $\pm 0.5\%$ of reading $\pm$ one digit. What is the possible error in volts when the instrument displays 2.00 V on the 10 V scale?
(a) 0.03 V  
(b) 0.02 V  
(c) 0.01 V  
(d) 0.005 V  
Ans. (b)

$3\frac{1}{2}$ DVM, $\text{Accuracy} = \pm 0.5\% + \text{1 digit}$

$FSD = 10 \text{ V}, \quad \text{Reading} = 2 \text{ V}$

$\text{error (1)} = \pm 0.5\% \text{ of reading}$

$= \pm \frac{0.5}{100} \times 2 \text{ V} = \pm 0.01$

$1 \text{ digit} = \frac{V_{FSD}}{10^3} = \frac{10}{10^3} = 0.01 \Rightarrow \text{error (2)}$

$\text{Total error} = \text{error (1)} + \text{error (2)}$

$= 0.01 + 0.01 = 0.02 \text{ V}$

100. A megger is an instrument used for measuring:
(a) Very high voltages  
(b) Very low voltages  
(c) Very high resistances  
(d) Very low resistances  
Ans. (c)

101. The values of capacitance and inductance used in the series LCR Circuit are 160 pF and 160 µH with the inherent tolerance -10% in each. Then, the resonance frequency of the circuit is in the range of:
(a) 0.8 MHz to 1.2 MHz  
(b) 0.9 MHz to 1.0 MHz  
(c) 0.8 MHz to 1.0 MHz  
(d) 0.9 MHz to 1.2 MHz  
Ans. (b)

Given that $L = (160 \pm 10\%) \mu \text{H} = (160 \pm 16) \mu \text{H}$

$C = (160 \pm 10\%) \text{ pF} = (160 \pm 16) \text{ pF}$

by considering maximum values $\Rightarrow L = 176 \mu \text{H}, C = 176 \text{ pF}$

$\omega = \frac{1}{2\pi \sqrt{LC}} = \frac{1}{2\pi \sqrt{176 \times 10^{-6} \times 176 \times 10^{-12}}} = 0.9 \text{ MHz}$

by considering maximum values $\Rightarrow L = 144 \mu \text{H}, C = 144 \text{ pF}$

$\omega = \frac{1}{2\pi \sqrt{144 \times 10^{-6} \times 144 \times 10^{-12}}} = 1.09 \text{ MHz}$
102. Dynamic characteristics of instruments leading to variations during measurement are:
   1. Speed of response  
   2. Fidelity  
   3. Dynamic error
Which of the above are correct?
(a) 1 and 2 only  
(b) 1 and 3 only  
(c) 2 and 3 only  
(d) 1, 2 and 3

Ans. (a)

103. The reliability of an instrument refers to:
   (a) Degree to which repeatability continues to remain within specified limits
   (b) The extent to which the characteristics remain linear
   (c) Accuracy of the instrument
   (d) Sensitivity of the instrument

Ans. (a)

104. AC Voltmeters use diodes with:
   (a) High forward current and low reverse current ratings
   (b) Low forward current and low reverse current ratings
   (c) Low forward current and high reverse current ratings
   (d) High forward current and high reverse current ratings

Ans. (a)

105. The bridge circuit shown can be used to measure unknown lossy capacitor $C_x$ with resistance $R_x$. At balance:

![Bridge Circuit Diagram]

(a) $R_x = \frac{C_1}{C_3} R_2$ and $C_x = \frac{R_1}{R_2} C_3$
(b) $R_x = \frac{C_1}{C_2} R_1$ and $C_x = \frac{R_2}{R_1} C_3$
(c) $R_x = \frac{R_1}{C_2} R_2$ and $C_x = \frac{C_1}{R_1} R_2$
(d) $R_x = R_2$ and $C_x = C_3$

where $R_1$, $R_2$, $C_1$, and $C_3$ can be assumed ideal components.
Ans. (a)

\[ R_2 \frac{1}{j\omega C_3} = R_1 \frac{1}{1+j\omega C_1} \left( R_x + \frac{1}{j\omega C_3} \right) \]

\[ \frac{R_2}{j\omega C_3} (1 + j\omega C_1 R_1) = R_x R_1 + \frac{R_1}{j\omega C_3} \]

\[ \frac{R_2}{j\omega C_3} (\frac{j\omega C_1 R_2}{j\omega C_3}) = R_x R_1 + \frac{R_1}{j\omega C_3} \]

On comparing real and imaginary part

\[ R_x R_1 = \frac{C_1 R_2}{C_3} \]

\[ \therefore \]

\[ R_x = \frac{C_1 R_2}{C_3} \]

\[ \frac{R_2}{j\omega C_3} = \frac{R_1}{j\omega C_3} \]

\[ C_x = \frac{R_1}{R_2} C_3 \]

---

106. Inductance of a coil having Q value in the range of \((1 < Q < 10)\), can be measured by using:
(a) Hay’s bridge  
(b) De Sauty’s bridge 
(c) Maxwell’s bridge  
(d) Carry Foster’s bridge

Ans. (c)

---

107. The instrument servomechanism is actually an instrument system made of components, which are:
(a) Exclusively passive transducers  
(b) Exclusively active transducers 
(c) Combination of passive transducers and active transducers  
(d) Exclusively primary sensing elements

Ans. (c)

---

108. The scale of an electrodynamometer usually reads the:
(a) Average value of the ac  
(b) Mean value of the ac 
(c) Effective value of the ac  
(d) Squared value of the ac

Ans. (c)
109. The resolution of an indicating instrument can be defined as:
1. Variation in the meter reading for the same applied input
2. Detectable change in the deflection due to smallest change in the applied input
3. Detectable change in the output due to drifting of pointer
Which of the above statements are correct?
(a) 1 only
(b) 2 only
(c) 3 only
(d) 1 and 3
Ans. (b)

110. While measuring the phase difference between the signals \( v_1(t) = 10 \sin \omega t \) and \( v_2(t) = 10 \sin (\omega t + \phi) \), the Lissajous pattern observed on CRO is a circle. The value of \( \phi \) is:
(a) \( 2\pi \)
(b) \( \pi \)
(c) \( \frac{\pi}{2} \)
(d) \( \frac{\pi}{4} \)
Ans. (c)

111. The expected voltage across a resistor is 100 V. However, the voltmeter reads a value of 97 V. The relative error is:
(a) 0.97
(b) 0.03
(c) 0.07
(d) 3.00
Ans. (b)

\[
\text{Measured voltage} = V_m = 97 \text{ V} \\
\text{True voltage} = V_T = 100 \text{ V} \\
\text{Relative error} = \frac{V_m - V_T}{V_T} = \frac{97 - 100}{100} = -0.03
\]

112. A sinusoidal voltage of amplitude 150 V has been applied to a circuit having a rectifying device that prevents flow of current in one direction and offers a resistance of 15 Ω for the flow of current in the other direction. If hot wire type and PMMC type instruments are connected in this circuit to measure the electric current, their readings would respectively be:
(a) 3.18 A and 5 A
(b) 5 A and 3.18 A
(c) 3.18 A and 5 mA
(d) 5 A and 3.18 mA
Ans. (c)
Ans.  (b)

\[ I_{\text{avg}} = \frac{V_{\text{avg}}}{R} = \frac{150/\pi}{15} = 3.18 \text{ A} \]

\[ V_{\text{avg}} = \frac{V_{\text{avg}}}{\pi} = \frac{150}{\pi} \]

Hot wire (A) \[ I_{\text{RMS}} = \frac{V_{\text{RMS}}}{R} = \frac{V_m/\sqrt{2}}{R} \]

\[ I_{\text{RMS}} = \frac{150/\sqrt{2}}{15} = 7.07 \text{ amp} \]

113. A tachometer encoder can be used for measurement of speed:
   (a) of false pulses because of electrical noise
   (b) in forward and reverse directions
   (c) in one direction only
   (d) for single revolution in a multiple track

Ans.  (d)

114. A rotameter works on the principle of variable:
   (a) Pressure  \hspace{1cm} (b) Length
   (c) Area \hspace{1cm} (d) Resistance

Ans.  (c)

115. An input voltage required to deflect a beam through 3 cm in a Cathode Ray Tube having an anode voltage of 1000 V and parallel deflecting plates 1 cm long and 0.5 cm apart, when screen is 30 cm from the centre of the plates is:

   (a) 300 V  \hspace{1cm} (b) 200 V
   (c) 100 V \hspace{1cm} (d) 75 V

Ans.  (c)

Given that

\[ D = 3 \text{ cm} = 3 \times 10^{-2} \text{ m} \]
\[ l_d = 1 \text{ cm} = 1 \times 10^{-2} \text{ m} \]
\[ d = 0.5 \text{ cm} = 0.5 \times 10^{-2} \text{ m} \]
\[ V_a = 1000 \text{ volt} \]
\[ L = 30 \text{ cm} = 30 \times 10^{-2} \text{ m} \]
\[ D = \frac{V_d \cdot L \cdot I_d}{2V_a \cdot d} \]
\[ \Rightarrow \quad V_d = \frac{D \times 2V_a \cdot d}{L \cdot I_d} \]
\[ V_d = \frac{3 \times 10^{-2} \times 2 \times 1000 \times 0.5 \times 10^{-2}}{30 \times 10^{-2} \times 1 \times 10^{-2}} = 100 \text{ volt} \]

116. A 6-bit ADC has a maximum precision supply voltage of 20 V. What are the voltage changes for each LSB present and voltage to be presented by (100110), respectively?
(a) 0.317 V and 12.06 V  
(b) 3.17 V and 12.06 V  
(c) 0.317 V and 1.206 V  
(d) 3.17 V and 1.206 V

Ans. (a)  
Given 6 bit converter that maximum voltage = 20 volt  
for maximum voltage  \( \Rightarrow \quad 1 \uparrow 1 \uparrow 1 \uparrow 1 \uparrow 1 \uparrow 1 = 20 \text{ volt} \)
\( \downarrow \downarrow \downarrow \downarrow \downarrow \downarrow \)  
\( (32 + 16 + 8 + 4 + 2 + 1) = 63 \text{ volt} \)
\( 63 = 20 \text{ volt} \)
\( \Rightarrow \quad 1 = \frac{20}{63} = 0.317 \text{ presion} \)
measured  \( \Rightarrow \quad 100110 \Rightarrow [(1.32) + 0 + 0 + (1 \times 4) + (1 \times 2) + 0] \times 0.317 \)
\( \Rightarrow 12.06 \text{ volt} \)

117. Which of the following transducers measures the pressure by producing emf as a function of its deformation?
(a) Photoelectric transducer  
(b) Capacitive transducer  
(c) Inductive transducer  
(d) Piezoelectric transducer

Ans. (d)

118. Maxwell's bridge measures an unknown inductance in terms of:
(a) Known inductance  
(b) Known capacitance  
(c) Known resistance  
(d) Q of the coil

Ans. (b)
119. Strain gauges are constructed with Germanium chips because Germanium:
(a) has a strong Hall Effect
(b) is crystalline in nature
(c) can be doped
(d) has piezoelectric property
Ans. (c)

120. The advantages of an LVDT is/are:
1. Linearity  2. Infinite resolution  3. Low Hysteresis
Which of the above advantages is/are correct?
(a) 1 only  (b) 2 only
(c) 3 only  (d) 1, 2 and 3
Ans. (d)