

INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY
DEPARTMENT OF AVIONICS

Satellite and Optical Communication (AV412)

B.Tech Electronics and Communication, **Quiz 1**

Answer all questions. Every steps of any derivations must be logically explained.

Date: 13/09/22, Total Mark: 15

1. Neo receives a 7-bit string, $[D_1 D_2 D_3 D_4 P_1 P_2 P_3]$ from Morpheus, sent using a code C, with parity equations

$$P_1 = D_1 + D_2 + D_3$$

$$P_2 = D_1 + D_2 + D_4$$

$$P_3 = D_1 + D_3 + D_4$$

- a. Write down the generator matrix G, for C. [1.5 marks]
- b. Write down the parity check matrix H, for C. [1.5 marks]
- c. What is the error detection and correction capability of the code? [2 marks]
2. Consider a planar dielectric waveguide whose substrate has a refractive index (RI) of 1.56, guiding layer of RI=1.6 and free space as its cover material. Calculate the minimum angle with respect to the normal with which a ray of light can be incident at the guide-cover or guide-substrate interface so that it still remains confined to the guiding layer and can undergo total internal reflection. [5 marks]
3. An optical fiber of core refractive index n_1 and cladding index n_2 is placed in a medium whose index is given by n. For this arrangement, obtain an expression for the maximum acceptance angle so that light launched can undergo total internal reflection. For this arrangement, define what numerical aperture is, and explain its significance. [5 marks]

INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY

THIRUVANANTHAPURAM, 695 547

B. Tech Seventh Semester ECE – Quiz 1 – September 2022

AV411 – Navigation Systems and Sensors

Time: One hour Date: 12/09/2021 Max. Marks: 15

Read **ALL** the instructions in this **NOTE**. Write your name and ID number on Answer Papers. Do **NOT** panic. Answer **ALL** questions. All the steps must be stated clearly. The steps carry more marks than the final answer. Provide illustrations wherever required.

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1. Define Navigation, Guidance and Control and explain the NGC loop using a neat block diagram. (3)
2. With a neat block diagram explain briefly the the concept of stabilised platform system. (3)
3. Define synodic coordinate system with Earth and Moon as primary and secondary bodies respectively. (3)
4. With a suitable diagram, define the ECEF coordinate system and the NED coordinate system at a station whose Geodetic Latitude is $\Phi = \pi/4$ radians) and Longitude is $\lambda = \pi/4$ radians. Obtain the expression for the DCM(Direction Cosine Matrix) for NED to ECEF transformation and evaluate the matrix. (3)
5. Let \vec{v} be a vector which is rotated with respect to the axis of rotation along the unit vector \vec{u} by an angle θ . With a neat diagram derive the solution to express the final rotated vector \vec{v}' in terms of \vec{u}, \vec{v} and θ . (3)



Institute Elective Course Quiz-1
AVD 888: Complex Networks, Aug-Dec 2022

Name:

Student ID:

Date: 22/09/2022

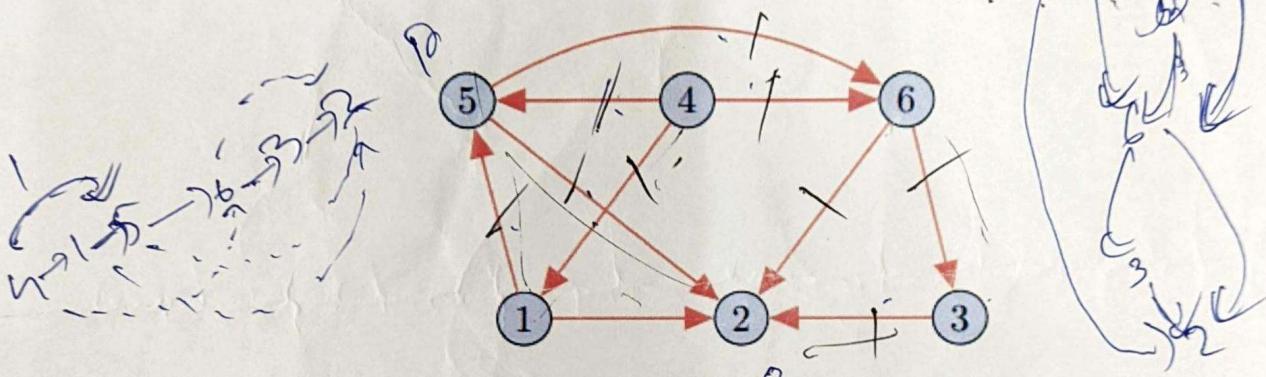
Duration: 1 hour

Max Score: 15

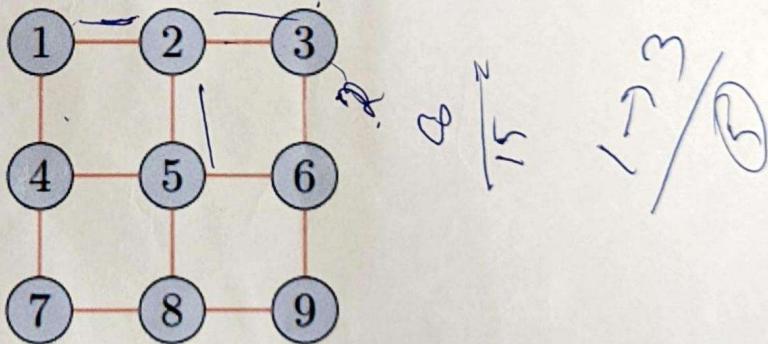
Make suitable assumptions, if necessary, and clearly state them. Answers should be marked with question/branch question numbers properly. Clear and legible steps are important for answers.

COx stands for Course Objective x which can be ignored by students as these notations are used by the instructor for Outcome Based Education with Multi-track Modular Teaching in order to enhance the teaching-learning process at IIST.

1. [CO1] (3 points) For the graph shown in figure below, use acyclicity test and find out the cycles, if any.



2. [CO1] (3 points) Estimate the precedence graph of the network referred in Problem 1 above.
3. [CO1 and CO2] (3 points) For the given network in figure below, estimate the following: (i) Degree Centrality (DC), (ii) Closeness Centrality (CC), and (iii) Betweenness Centrality (BC).



4. [CO2] (3 points) Under what conditions, the degree distribution of an E-R random network changes? To which distribution it changes? Discuss with detailed explanation.
5. [CO2 and CO3] (2 points) Compare and contrast small-world networks with random and regular networks.
6. [CO2, CO3, and CO5] (1 point) Briefly describe your Track-3 Dataset and Data analysis idea and objectives.

-----All the best-----

$$V(D) = V^{(6)}(D) + D \times V^{(4)}(D^4)$$

(Baud. D)
SMBORR

$$V(D) = U^{(6)} \times g +$$

INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY

THIRUVANANTHAPURAM, 695 547

B.Tech Quiz-II – October 2021

AV 412 – Satellite and Optical Communication

Time: 1 hour

Date: 20/10/2022

Max. Marks: 15

Answer the following

- Verify that the generator polynomial $g(X) = 1 + X + X^2 + X^3$ generates a binary cyclic code C(8, 5) and determine the code vector for the message vector $m = (10101)$ in systematic form using the encoding circuit. [4]
- Determine the length and technique to correct the burst error using cyclic codes. [3]
- Determine the generate sequence and the time domain equation for the encoder in Figure 1. [3]

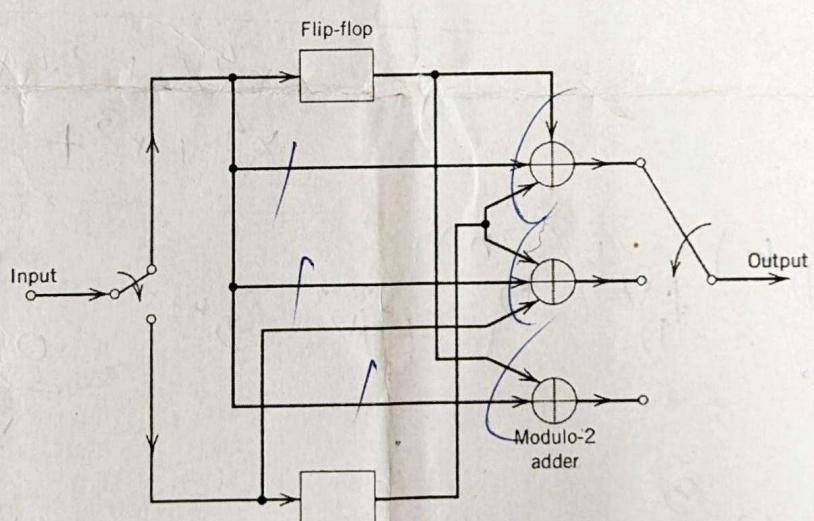


Figure 1:

- Prove that, by using a laser diode, chromatic dispersion can be the least in optical fibers. [3.5]
- Optical power of 5 mW coupled into an optical fiber reduces to 3.8 mW after propagating through a distance of 10 km. Determine the attenuation coefficient α of this fiber in dB/km. [1.5]

INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY

THIRUVANANTHAPURAM, 695 547

B. Tech Seventh Semester ECE – Quiz 2 – October 2022

AV411 – Navigation Systems and Sensors

Time: One hour Date: 19/10/2022 Max. Marks: 15

Read **ALL** the instructions in this **NOTE**. Write your name and ID number on Answer Papers. Do **NOT** panic. Answer **ALL** questions. All the steps must be stated clearly. The steps carry more marks than the final answer. Provide illustrations wherever required.

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1. With neat diagrams, show that the quaternion operator $L_p(\vec{q}) = p^* \vec{q} p$ with $\|p\| = 1$ represents rotation by clearly showing the axis of rotation and angle of rotation. (5)
2. Derive the Euler angle rates in terms of body axis angular rates for rotation along Y and Z axes by using perturbations of rotations. Assume that the perturbed rotation matrix to be $S = QR$, where Q is the unperturbed rotation matrix and R is the incremental rotation. Assume the basic rotation operation to be $Q_\theta Q_\psi$ where Q_θ is w.r.t Y and Q_ψ is w.r.t Z. (5)
3. Show that rotation matrices are orthogonal matrices with determinant 1. (2)
4. Find the quaternion corresponding to the DCM matrix (3)

$$\begin{bmatrix} -\frac{5}{8} & \frac{\sqrt{3}}{4} & \frac{3^{3/2}}{8} \\ \frac{\sqrt{3}}{4} & -\frac{1}{2} & \frac{3}{4} \\ \frac{3^{3/2}}{8} & \frac{3}{4} & \frac{1}{8} \end{bmatrix}$$



Indian Institute of Space Science and Technology (IIST)
Department of Avionics [www.iist.ac.in]

Institute Elective Course Quiz-II
AVD 888: Complex Networks, Aug-Dec 2022

Name:

Student ID:

Date: 01/11/2022

Duration: 1 hour

Max Score: 15

Make suitable assumptions, if necessary, and clearly state them. Answers should be marked with question numbers properly. Clear and legible steps are important for answers.

COx stands for Course Objective x which can be ignored by students as these notations are used by the instructor for Outcome Based Education with Multi-track Modular Teaching in order to enhance the teaching-learning process at IIST.

- 1. [CO1 and CO2] (3 points) What are anchor points? Explain with an example and in detail. What is the most likely reason behind the unique locations of anchor points in the case of a string topology network?
- 2. [CO2, CO3, and CO5] (2 point) Explain in details the results you obtained in your Track-3 Data analysis.
- 3. [CO1 and CO2] (3 points) Describe the Kleinberg model for creating a small-world network. What is the relevance of clustering exponent? Describe the major characteristics of clustering exponent.
- 4. [CO1] (4 points) Consider a Small-World Wireless Sensor Network (SW-WSN). Under what conditions, a SW-WSN can provide energy efficiency. Derive your answer.
- 5. [CO1, CO2, CO3] (3 points) How do you determine if a given large network has small world property? Explain in details.

-----All the best-----

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2 347 260

Please answer Part A and Part B in separate sheets

Part A-Satellite Communication

1. A receiver front end (RF front end) has a noise figure of 10 dB, a gain of 80 dB, and a bandwidth of [6 MHz]. The input signal power is 10^{-11} W. Assume that the line is lossless and the antenna temperature is 150 K.
 - (i) Find system noise temperature, $(C/N)_{input}, (C/N)_{output}$ [3]
 - (ii) If a preamplifier is used before the receiver front end with a noise figure of 3 dB, a gain of 13 dB. Find the improvement in $(C/N)_{output}$ [2]
 - (iii) If a coaxial feeder is connected between the preamplifier and receiver front end and has a loss of 2 dB, calculate the system noise temperature [2]
 - (iv) If a feeder cable is connected between the antenna and the preamplifier, calculate the system noise temperature and Comment on the result. [3]
2. (i) Draw the block-level diagram for the bent-pipe and regenerative transponder. [4]
 - (ii) Derive the overall C/N ratio for bent-pipe transponder. [3]
 - (iii) The following parameters apply to a satellite downlink: EIRP 22.5 dBW, free-space loss 195dB, other losses 1.5 dB, earth station (G/T) 37.5 dB/K. Calculate the $(C/N)_o$ at the earth station. Assuming an output Back off power of 6dB is applied, what is the new value of $(C/N)_o$? [3]
3. (i) A data link transmits 7-bit ASCII words at a bit rate of 1 Mbps with a single parity bit. The probability of a bit error on the link is $p = 10^{-3}$. Find the probability of an undetected error when uncoded data is transmitted and when a single parity bit is added to each 7-bit word [decoder can detect 1 and 3-bit error]. What is the probability of an undetected bit error when BER on the link is 10^{-6} for both cases? [4]
 - (ii) A LEO satellite is in a circular polar orbit with an altitude h of 1000 km. A transmitter on the satellite has a frequency of 2.6GHz. The mean radius of the earth is 6378km. Find the velocity of the satellite in orbit. [3]
 - (iii) What is the advantage and disadvantage, if communication satellites are placed in LEO and GEO orbit? [3]
4. A convolutional code is described by $g_1 = [110] \quad g_2 = [101] \quad g_3 = [111]$. Find the transfer function and free distance for this code. [10]
5. (i) Design a Meggitt decoder circuit for (7,4) cyclic code generated by $g(x) = 1 + x^2 + x^3$. [6]
 - (ii) When linear block code is called self dual code? [2]
 - (iii) What is the dual code for repetition code and why it is called dual code? [2]

110 101 1 1 1.

Part B-Optical Communication

6. Using energy band diagrams, explain the operation of an Erbium Doped Fiber Amplifier. What is the importance of metastable state in the energy band diagram? What are the sources of noise in this amplifier? Can a two level system work as a laser? Explain. [8]
7. A fibre optic communication link has the following parameters. (i) Source power = 0 dBm (ii) Detector sensitivity = -45 dBm (iii) Connector loss = 1 dB/connector (iv) Splice loss = 0.06 dB/Splice. If the total link length of 100 km is spanned by connecting two-hundred 500 m cables of attenuation coefficient 0.3 dB/km and a system margin of 5 dB is required, determine whether or not an amplification of the optical signals is required in the link. If yes, determine the required minimum amount of amplification in dB. Assume that the fibre cables are connected to the source, detector and amplifier using connectors and individual fibre cables are connected through splicing. [8 marks]
8. Define Quantum efficiency and Responsivity of a Photodiode. Use a graph to show how the responsivity vary as a function of photon wavelength for a photodiode? Define cut-off wavelength for a Photodiode. What are the draw backs of conventional p-n photodiode? How does p-i-n photodiodes help in overcoming them? What parameters of the diode decide its dark current? [8 marks]
9. A quantum well laser is to be designed using $\text{GaAs}/\text{Al}_x\text{Ga}_{1-x}\text{As}$ with GaAs as the active layer. The thickness of the active layer is 10 nm and the Al composition for the barrier is 0.3. Given that ΔE_c is 60 % of ΔE_g and $\Delta E_v = 40$ % of ΔE_g ; where ΔE_g is the bandgap difference between $\text{Al}_x\text{Ga}_{1-x}\text{As}$ and GaAs. Assuming that the effective mass of the electron is $0.067 m_0$ and that of hole is $0.082 m_0$ where m_0 is the rest mass of the electron, calculate the wavelength of the photon emitted from this laser. Assume that the bandgap of $\text{Al}_x\text{Ga}_{1-x}\text{As}$ is $1.424 + 1.248x$ eV [8]
10. A phase modulator made of LiNbO_3 has rectangular cross-section shaped waveguide made by diffusing Ti into LiNbO_3 having an index of 2.355 while the refractive index of LiNbO_3 is 2.30. The diffused waveguide is $3 \mu\text{m}$ wide and has a depth of 500 nm. A Silica step index single mode optical fiber which has a clad index of 1.55 and a core index which is 1% higher than that of the clad index has to be coupled at the Input and Output ports of the modulator. Explain the various coupling losses that can occur in this scheme and techniques to minimize them. How do you ensure that the fiber is mechanically well connected with the LiNbO_3 substrate? [8]
11. For a symmetric dielectric slab waveguide of core index n_g and cladding index n , derive the expression for the V parameter and use it to obtain the eigenvalue equation for the symmetric TE mode. What is the significance of V parameter in designing single mode waveguides? [8]
12. Mention the approximate wavelength at which Silica optical fiber has the least dispersion and least attenuation. [2]

INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY
THIRUVANANTHAPURAM, 695 547

B. Tech Seventh Semester ECE – End Semester – December 2022

AV411 – Navigation Systems and Sensors

Time: Three hours Date: 01/12/2022 Max. Marks: 50

Read **ALL** the instructions in this **NOTE**. Write your name and ID number on Answer Papers. Do **NOT** panic. Answer **ALL** questions. All the steps must be stated clearly. The steps carry more marks than the final answer. Provide illustrations wherever required.

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1. An archer in the Ayodhya, ancient India observes a bird flying due North. He wishes to bring down the bird. So he faces North and shoots the arrow. Assuming both the bird and the arrow to be point objects with the mass of bird and arrow, respectively, will the archer succeed in bringing down the bird. Justify your answer. If not, then how does the arrow move in relation to the North direction? Justify your answer. (2)
2. Foucault Pendulum
 - (a) What is the direction of rotation of vibrational plane of a Foucault's pendulum located in Perth, Australia? Justify. (2)
 - (b) An observer is located at the equator uses Foucault's pendulum to detect the rotation of earth. Will the observer succeed? Why? (2)
3. Derive the two different ways in which the expression for the moment inertia term occurs in a rotating rigid body. Hint: Consider kinetic energy and angular momentum. (4)
4. The tensor of inertia matrix for a certain rigid body with respect to the standard basis is given to be (3)

$$\Theta = \begin{bmatrix} 4 & -2 & -1 \\ -2 & 5 & -2 \\ -1 & -2 & 6 \end{bmatrix}$$

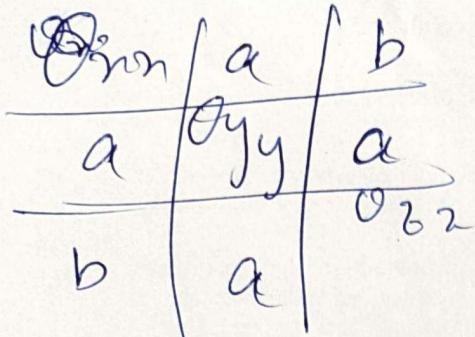
It is given that moment of inertia about a particular axis \hat{n} is 12.

Is \hat{n} unique. If so justify and compute \hat{n} . Otherwise, state/derive the equations which lead to computing the vector \hat{n} .

5. State the properties of Tensor of Inertia matrix. (3)
6. For planar mass show that $\Theta_{zz} = \Theta_{xx} + \Theta_{yy}$ (2)
7. Which of the following are candidates for tensor of inertia: Justify. (3)

$$\Theta_1 = \begin{bmatrix} 4 & 3 & 1 \\ 2 & 5 & 2 \\ 4 & 3 & 6 \end{bmatrix} \quad \Theta_2 = \begin{bmatrix} 4 & -2 & -1 \\ -2 & 5 & -2 \\ -1 & -2 & 6 \end{bmatrix} \quad \Theta_3 = \begin{bmatrix} 4 & -3 & -1 \\ -2 & -5 & -2 \\ -1 & -2 & 6 \end{bmatrix}$$

8. A spinning wheel pivoted by a frictionless support is rotating with angular velocity w as shown in Fig. 1.
 - (a) What is the direction of the angular velocity vector? (1)



(1)

$\begin{bmatrix} \text{On } x \\ \text{On } y \\ a \\ b \end{bmatrix} \quad \begin{bmatrix} a \\ b \end{bmatrix} \quad \begin{bmatrix} \text{On } z \end{bmatrix}$

(b) Are there any torques at the support point? Justify.

(c) If there is a torque at the support point what force is the cause for it and give the direction of the torque vector.

(d) Does the unsupported end move? If so in what direction will the unsupported end move? Assuming that the precession due to torque is given by precession \times angular momentum = torque, Justify.

9. Define moment of couple and show that torque due to couple is independent of the choice of the coordinate system. (2)

10. A rigid body consists of 4 particles of mass m , $2m$, $3m$ and $4m$, respectively situated at points (a, a, a) , $(a, -a, -a)$, $(-a, a, -a)$, $(-a, -a, a)$, and connected together by a massless framework.

(a) Find the tensor of inertia matrix (5)

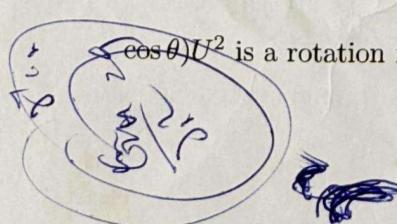
(b) Determine the torque required to rotate the rigid body in free space at constant angular velocity of 2 rad/s along x axis (2)

(c) Compute the principal axis and principal moments of inertia (6)

11. Consider an accelerometer mounted on a nanosatellite InspireSat1. The satellite is placed in the polar orbit (approximately 530km above the surface of Earth). Compute the acceleration measured by the accelerometer by assuming the acceleration due to gravity at the height of 700km above the Earth is 9.66 m/s^2 . Justify your answer. (1)

12. An inertial measuring unit consisting of three rate gyroscopes and three servo accelerometers are placed in a rocket at the launchpad located in Sydney, $33.8600^\circ \text{ S}, 151.2094^\circ \text{ E Australia}$. The input axes of the inertial measuring unit are aligned with North, East and Zenith axis. Determine the measurements obtained by all the gyroscopes and accelerometers. (3)

13. Let $\vec{u} = (a, b, c)$ be a unit vector and $\theta \in [0, \pi]$. Then show that $A = I + (\sin \theta)U + (1 - \cos \theta)U^2$ is a rotation matrix where $U = \begin{bmatrix} 0 & -c & b \\ c & 0 & -a \\ -b & a & 0 \end{bmatrix}$ (6)



C ab ch d h

Indian Institute of Space Science and Technology (IIST)
Department of Avionics [www.iist.ac.in]



Institute Elective Course Finals
AVD 888: Complex Networks, Aug-Dec 2022

Name:
Student ID:
Date: 08/12/2022

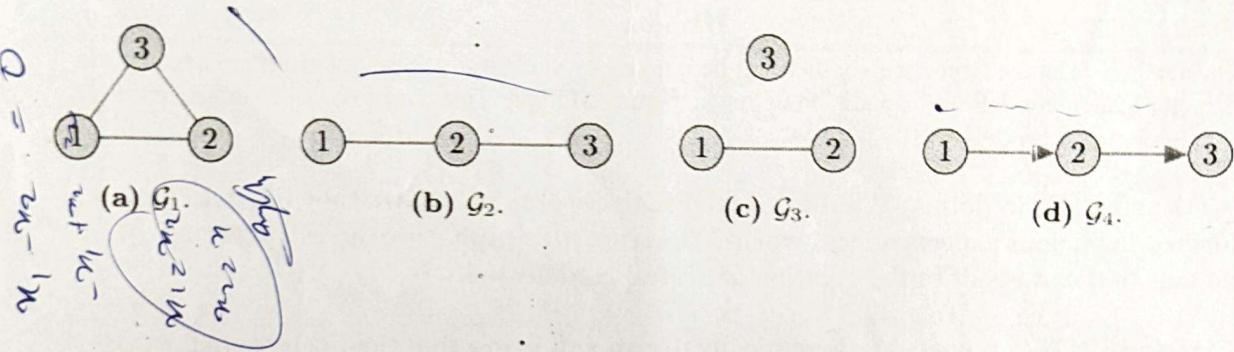
Duration: 3 hours

Max Score: 50

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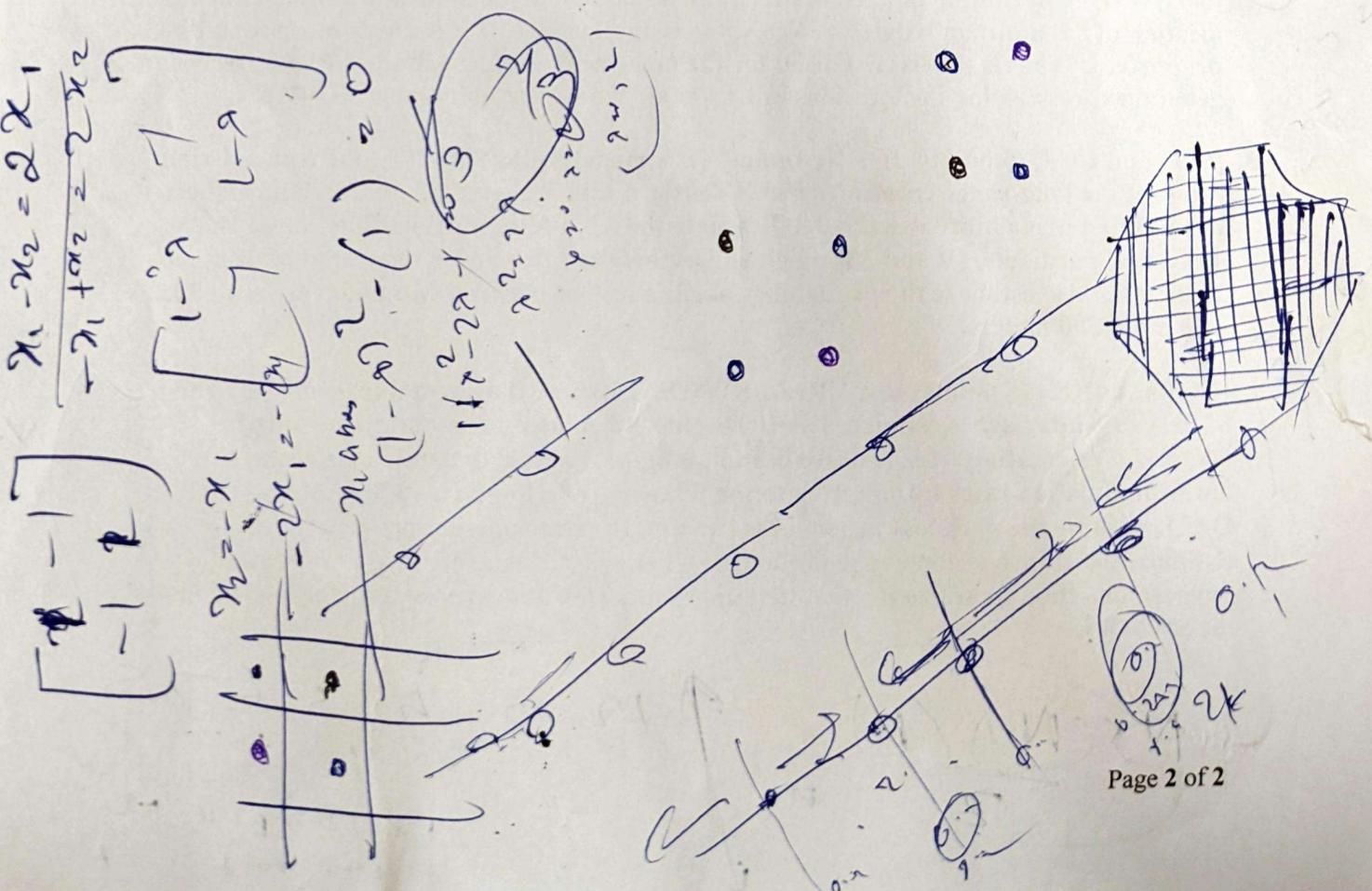
1. [CO1 and CO2] (5 points) What are ScaleFree networks? How are they likely to be formed in various aspects of real-world? Describe the graph growth/restructuring models that can result in the creation of Scale-Free networks.
 2. [CO1 and CO2] (5 points) Mathematically derive and prove that the Preferential Attachment method results in Scale-Free network formation.
 3. [CO1, CO2, CO3, and CO5] (5 points) Derive scaling coefficient for the following scenario. At time $t = 0$, there are n_0 nodes with average degree of 2. At $t = 1$, a new node is introduced which connects to k nodes ($k \leq n_0$) of the already existing network. k links that are added from the newly introduced node to an already existing node based on the lower value of degree distribution. Estimate the expression for scaling coefficient when new nodes are added for long elapsed time, i.e., $t \gg 1$.
 4. [CO1, CO2, and CO5] (5 points) Consider an N-node string topology WSN transformed to a SWWSN by adding one LL between the BS and the node at location $N/2$. While the location of LL addition halves the WSN, the reduction in APLB is much more than its proportion. What is the likely reason for the non-linear decrease in the APLB? Derive a general expression for the locations of LLs in an N node string topology SWWSN.
 5. [CO1 and CO2] (5 points) In a Newman-Watts model based SWWSN, the transmission range of the long-range transmitter of H-sensor nodes is about 250 meters. The highest LL addition probability is set to 0.8. Estimate the LL addition probability, p , for the structural parameters 2 and 3 for a given link between two nodes separated at distance 20 meters. Also estimate the probability of LL addition between two nodes separated by a distance 300 meters.
 6. [CO1 and CO2] (5 points) In a VRAM-SWWSN, assume the normal transmission range of the radio interface is estimated as 100 meters when using a modulation rate of 64QAM. For creating LLs, rate adaptation is employed in a dynamic manner to two lower modulation rates by adapting to the following two levels: (a) 32 QAM and (b) 8 QAM. Assume the path loss exponent is two and the transmission power is fixed. Estimate the transmission range of the LLs when operating at the two lower rates. Suggest a method to utilize the two LL ranges in a way to achieve energy efficiency in the SWWSN.

7. [CO1 and CO2] (5 points) Explain the operation of Conflict Graph Transform based Community Detection (CTCD) with examples. What are the advantages of CTCD?
8. [CO1 and CO2] (5 points) Find the adjacency and Laplacian spectra of the graphs shown in the figure below.



9. [CO1, CO2, and CO3] (3 points) Explain why the spectrum of a graph is independent of vertex labelling. Prove that the Laplacian of an undirected graph has non-negative eigenvalues.
10. [CO1, CO2, CO3, and CO5] (7 Points) Describe the important metrics, algorithms, dataset, and algorithms used for your Track-4 project. Also explain the key observations and results, and the novelty of your work. Draw figures wherever necessary.

-----All the best-----



INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY
THIRUVANANTHAPURAM, 695 547

Satellite Communication Course

(To be done)
Military College of Electronics and Mechanical Engineering
Hyderabad

Tutorial-

1. A C-band earth station has an antenna with a transmit gain of 54dB. The transmitter output power is set to 100 W at a frequency of 6.1 GHz. The signal is received by a satellite at a distance of 37,500 Km by an antenna with a gain of 26 dB. The signal is then routed to a transponder with a noise temperature of 500 K, a bandwidth of 36MHz, and a gain of 110dB.

- a) Calculate the path loss at 6.1 GHz.
b) Calculate the power at the output port (sometimes called the output wave guide flange) of the satellite antenna, in dBW.
c) Calculate the noise power at the transponder input, in dBW, in a bandwidth of 36 MHz.
d) Calculate the C/N ratio, in dB, in the transponder.
e) Calculate the carrier power, in dBW and in W, at the transponder output
2. A 14/11 GHz satellite communication link has a transponder with a bandwidth of 52 MHz which is operated at an output power level of 20 W. The satellite transmit antenna gain at 11 GHz is 30 dB towards a particular earth station. Path loss to this station is 206 dB, including clear air atmospheric loss.

The transponder is used in FDMA mode to send 500 BPSK voice channels with half rate FEC coding. Each coded BPSK signal has a symbol rate of 50 kbps and requires a receiver with a noise bandwidth of 50 kHz per channel. The earth stations used to receive the voice signal have antennas with gain of 40 dB (1 m diameter) and a receiver with $T_{system} = 150$ K in clear air, and IF noise band width of 50 kHz.

- a) Calculate the power transmitted by the satellite in one voice channel.
b) Calculate the C/N in clear air for an earth station receiving one BPSK voice signal.
c) What is the margin over a coded BPSK threshold of 6 dB?
3. Geostationary satellite use L, C, Ku, and Ka bands. The path length from an earth station to the GEO satellite is 38,500 km. For this range, calculate the path loss in decibels for the following frequencies:
- a) 1.6 GHz, 1.5 GHz
b) 6.2 GHz, 4.0 GHz
c) 14.2 GHz, 12.0 GHz

d) 30.0 GHz, 20.0 GHz

4. Low earth orbit satellite use mainly L band, with ranges varying from 1000 to 2500 km. Calculate the maximum and minimum path loss from earth to a satellite, in dB, for the uplink frequency of 1.6 GHz, and the downlink frequency of 1.5 GHz.
5. A geostationary satellite carries a transponder with a 20 W transmitter rat 4 GHz. The transmitter is operated at an output power of 10 W and drives an antenna with gain of 30 dB. An earth station is at the center of the coverage zone of the satellite, at a range of 38,500km. Using decibels for all calculations, find:
 - a) The flux density at the earth station in dBW/m^2 .
 - b) The power received by an antenna with a gain of 39 dB, in dBW.
 - c) The EIRP of the transponder in dBW.
6. Design a c- band receiving earth station to provide an overall clear air C/N of 13dB in a 27MHz IF noise bandwidth at a carrier frequency of 4.06 GHz. The antenna noise temperature is 20 K and the LNA noise temperature is 55K. You may assume a high gain LNA and ignore the noise generated in other parts of the receiver. The C - band satellite transponder is operated with 1 dB output backoff. Clear air atmospheric attenuation on the downlink and other losses total 0.5dB. Determine the diameter of the receiving antenna, assuming an aperture efficiency of 65% .The receiving terminal is located on the 3 dB contour of the satellite footprint.

Reminder: Overall C/N includes the effect of noise radiated by the satellite transponder.
7. Design a transmitting earth station to provide a clear air C/N of 30 dB in a Ku- band transponder at a frequency of 14.15 GHz. Use an uplink antenna with a diameter of 5 m and an aperture efficiency of 68 %, and find the uplink transmitter power required to achieve the required C—N. The uplink station is located on the 2 dB contour of the satellite footprint. Allow 1.0dB on the uplink for miscellaneous and clear air losses.
8. Design a Ku - band receiving earth station to provide an overall clear air C/N of 17 dB in a 27 MHz IF noise bandwidth at a carrier frequency of 11.45 GHz. The antenna noise temperature is 30 K and the LNA noise temperature is 110 K. You may assume a high gain LNA and ignore the noise generated in other parts of the receiver. Determine the diameter of the receiving antenna. The receiving terminal

is located on the 3 dB contour of the satellite footprint, and clear air attenuation on the path and other losses total 0.8 dB.

9. A direct broadcast television (DBS-TV) satellite is in geostationary orbit at 100° west longitude. It carries 16 transponders, each with saturated output power of 200W and a bandwidth of 25 MHz. The antenna on the satellite has a gain (on axis) of 34dB. The receiving terminals all use antennas with a circular aperture with a diameter of 18 inches and an aperture efficiency of 65 %. The noise bandwidth of the digital TV receiver is 20 MHz.

Use a distance to the GEO satellite of 38,500 km in your calculations.

- Shouldn't
be 16 please*
- a) Calculate the free space path loss and the receiving terminal antenna gain at 12.2 GHz.
 - b) Draw up a link budget for the downlink from the satellite to an earth station on the 3 dB contour of the satellite antenna beam. Assume that the satellite transmits at a power level of 180 W. Include a clear air atmospheric loss off 0.5 dB and miscellaneous losses of 0.2 dB in your downlink power budget.
 - c) The receiving terminal has a system noise temperature of 110 K in clear air. Draw up a noise power budget for the receiver using the receiver's noise bandwidth.
 - d) Calculate the clear air C/N ratio for the receiver with noise bandwidth of 20 MHz.

The minimum permissible C/N ratio is 10.0 dB. What is the clear air link margin?

- e) For 0.3 % of the time at the receiving location heavy rain causes 2 dB excess path attenuation and the system noise temperature of the receiver increases to 210K. Calculate the C/N under these rain conditions, and the link margin above the C/N threshold of 10.0 dB.
- f) Many of the DBS-TV system customers live inside the 2 dB contour of the satellite beam. Calculate the clear air link margin and 0.3 % time link margin for a receiver located on the 2dB contour of the satellite footprint.
- g) An uplink stations for DBS-Tv satellite described in Question 1 is located in Utah, and transmits digital TV signals to 16 transponders on the satellite using QPSK with three-quarter rate forward error correction. The transmit each station has a circular aperture efficiency of 65%. Each transponder operates

at a different carrier frequency in the 17 GHz band, and the RF channel noise bandwidth is 20 MHz. The noise temperature of the satellite receiver is 500 K (the satellite always looks toward the "hot" earth).

Use the values in the remaining parts of this question

Calculate the uplink path loss and the uplink antenna gain at 17.5 GHz.

- h) The gain of the receiving antenna on the satellite in the direction of Utah is 31 dB.

Draw up a clear air uplink budget for the link from the earth station to a single transponder on the satellite using a transmit power of P_t watts, and atmospheric and other losses of 1.0dB.

- i) Calculate the noise power at the input to the satellite receiver in a noise bandwidth of 20 MHz. Hence, find the uplink transmitter power required to achieve a C/N of 28 dB in the satellite transponder.
- j) The gain of the satellite transponder must be set to amplify the received signal at the transponder input to an output level of 180 W. Calculate the gain of the transponder in decibels. (Ignore the change in frequency in the transponder

When designing RF equipment, a common rule to avoid oscillation is to make the amplification at any given frequency no higher than 60 dB. How would you design a bent pipe DBS-TV transponder to provide the end to end gain that you calculated?

- k) The minimum permissible C/N in the transponder is 16.0 dB.

Calculate the clear air link margin for the uplink.

- l) Ignore the result you calculated for the downlink C/N in problem 1, and use a value 15 dB in this question. Convert the clear air uplink and downlink C/N values to power ratios, and then find the overall C/N, in dB, in the earth station receiving terminal. Use the following formula (where C/N values are ratios, not in dB) and give your answer in decibels:

$$1/(C/N)_{\text{overall}} = 1/(C/N)_{\text{up}} + (C/N)_{\text{down}}$$

Basant D

**Indian Institute of Space Science and Technology
Department of Humanities**

Quiz 1

(Institute Elective Course for B Tech final year students)
HS466 Space Economics and Policy

Date of Examination : 26.09.2022

Time of Examination : 9.00 am to 10.00 am

Maximum Marks : 15

I. Answer any twelve questions of the following in two sentences (0.5 Mark each)

1. STEP
2. IN-SPACe
3. Externalities
4. Club goods
5. SROI
6. Up-stream space economy
7. Free rider problem
8. Consumer Surplus
9. Linkage Effect
10. Year of the establishment of Dept of Space
11. Astrosat
12. What is BE & RE in Budget?
13. Solow growth model
14. Keynesian open economy model

II. Answer any three of the following (Three Marks each)

15. What is Space Economy? Explain the need for estimating space economy of India. What are its challenges?
16. Distinguish between MEC & MEI. Illustrate with example how do we estimate MEC? What factors affect the calculation of MEC?
17. What is Production Function approach? Explain it by using Cobb-Douglas Production function. Derive the output elasticity of Cobb-Douglas Production function.
18. Explain the evolutionary stages of Indian space program by using the methodology of Dr. K. Kasturirangan.
19. What do you mean by 'Public Good'? Distinguish between the public production and public provisioning of public good. Explain how we estimate the optimum quantity of public good.

Borath D.



Indian Institute of Space Science and Technology
 Department of Avionics
 AVM 613 Analog VLSI Circuits
 Quiz 1

Time: 1 hour

Max. marks: 15

Answer either Qn1 or Qn2 AND Qn 3 or Qn 4

For all the questions, assume the following:

$$V_{DD} = 3V$$

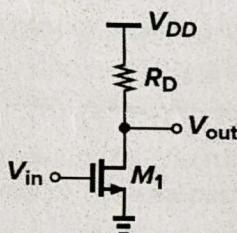
$$\mu_n C_{ox} = 1 \text{ mA/V}^2, V_{THN} = 0.7V.$$

$$\mu_p C_{ox} = 0.7 \text{ mA/V}^2, V_{THP} = -0.7V.$$

$$\lambda_N = 0.1, \lambda_P = 0.2.$$

You can assume square law model for MOSFET operation.

1. For the circuit shown below, W/L of NMOS is 7/0.5 and $R_D = 2 \text{ k}\Omega$.
 (9 marks)

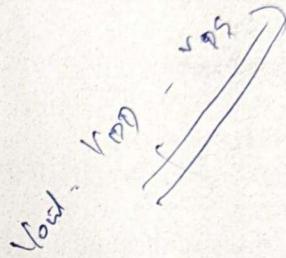
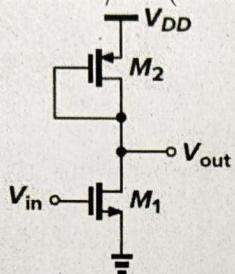


- (a) If the $V_{in,DC} = 1V$, what is the DC output bias voltage? (Neglect channel length modulation) (1 mark)
- (b) What is the effective transconductance of the circuit? (1 mark)
- (c) If the input voltage can be expressed as $V_{in} = 1 + 0.001 \sin(2\pi 1500t) \text{ V}$, write the expression for the drain current including the ac component. (1 mark)
- (d) What is the output impedance of the circuit? (You need to include the impact of channel length modulation as well) (1 mark)
- (e) What is the small signal gain of the amplifier? (1 mark)
- (f) If the total capacitance at the output node is 20 pF , what is the bandwidth of the amplifier? (You can assume this to be the dominant pole) (1 mark)
- (g) Derive the input referred voltage noise power spectral density for this amplifier. (2 marks)

- (h) If the gain is proposed to be increased by increasing R_D , what is the maximum value that it can take, while ensuring that the transistor is in saturation? (1 mark)

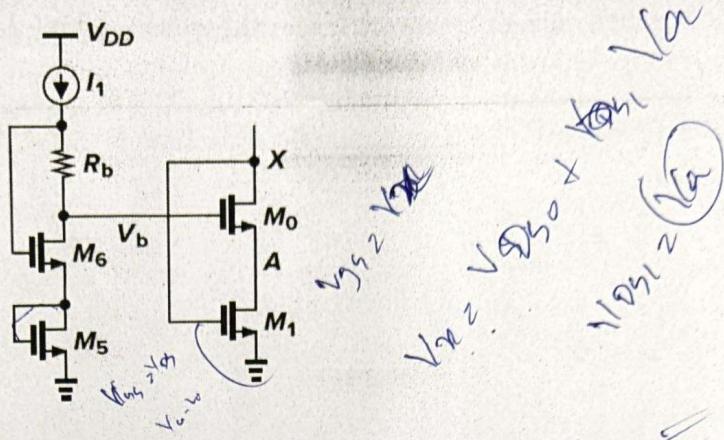
OR

2. For the circuit shown below, W/L of NMOS is 7/0.5 and the W/L of PMOS is 7/0.5 (9 marks)



- (a) If the $V_{in,DC} = 1V$, what is the DC output bias voltage? (Neglect channel length modulation) (2 marks)
- (b) What is the effective transconductance of the circuit? (1 mark)
- (c) What is the output impedance of the circuit? (You need to include the impact of channel length modulation as well) (2 marks)
- (d) What is the small signal gain of the amplifier? (1 mark)
- (e) If the total capacitance at the output node is 20pF, what is the bandwidth of the amplifier? (You can assume this to be the dominant pole) (1 mark)
- (f) Derive the input referred voltage noise power spectral density for this amplifier. (2 marks)

3. For the circuit shown below, assume all the transistors are identical and have a $W/L = 10/0.5$. Let $I_1 = 40 \mu A$ and V_A is designed to be 250 mV. (6 marks)



- (a) What is the V_{GS} of the transistors? (1 mark)

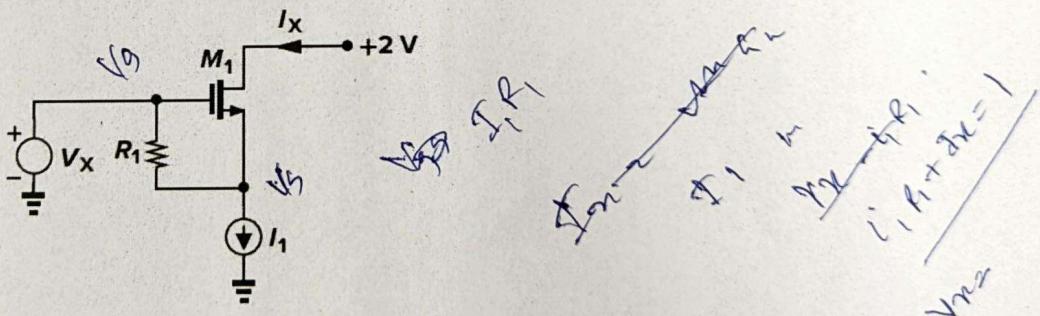
(b) What is the value of V_b required? (1 mark)

(c) What is the required value of R_b ? (1 mark)

(d) Consider a cascode current source biased using V_X and V_b for the bottom transistor and the cascode transistor respectively. Derive an expression for the output impedance of the cascode current source and calculate it if the same current ($40\mu A$) flows in the current source as well? (3 marks)

OR

4. For the circuit shown below, the voltage $V_X = 2V$, $R_1 = 5K$ and $I_1 = 1mA$, $W/L = 5/0.5$ (Neglect the effect of channel length modulation) (6 marks)



- (a) What is the value of V_{GS} in this circuit? (2 marks) [Hint: I_1 is the combination of the current through the transistor and R_1 .]

(b) What is the current I_X ? (1 mark)

- (c) Design a current mirror such that the current source I_1 is replaced with a MOS-based current source. You can derive the bias from a given standard current source of $100\mu\text{A}$. The maximum voltage that the current source is permitted to have is 250 mV. (3 marks)

INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY

Date: 19 Sept., 2022

Time: 1 Hour

Total Marks: 15

No. of Students: 47

Quiz-1

Dept. of Avionics

Sub. Name: Advanced Sensor & Interface Electronics (B. Tech VII Semester Elective)

Answer All Questions

Question 1

Fill in the blanks. Write the final answer in the script.

(3 Marks)

- SNR of a 12-bit ADC (reference voltage = 3.3 V), when applied with a input of 1.1 V is _____.
- Harmonic-content in the output of an ADC increases with _____ in amplitude of the input.
- In a Flash ADC, offset error can be introduced due to _____.
- Dynamic range of 8-bit unipolar ADC is _____.
- An 8-bit ADC, oversampled by a factor of 16, can improve the effective number of bits by _____.
- Second order All pass response can be obtained with the help of a _____ filter response.

Question 2

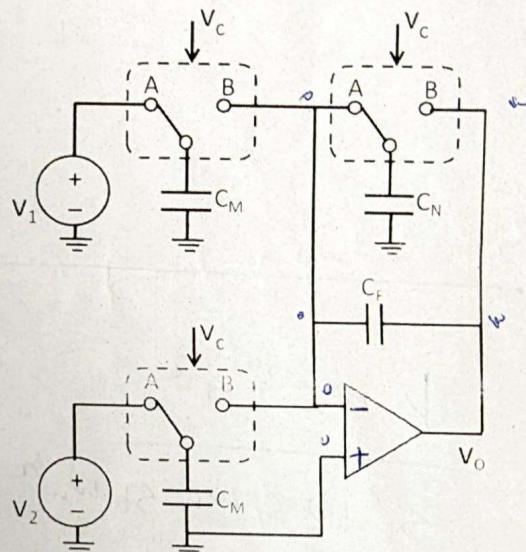
(4 Marks)

Draw the circuit of a HIGH-pass-filter circuit based on universal active filter topology. Design this circuit for a cut-off frequency = 1 kHz, damping ratio = 1, pass-band gain = 0 dB.

Question 3

(3 Marks)

Derive the expression for output voltage (V_o), in terms of the inputs V_1 and V_2 , of the circuit given in right. Assume that the frequency (say, f_c) of the clock signal (v_c) is sufficiently high when compared to the frequency of V_1 and V_2 . Switches will be at position A when v_c is high and at position B, otherwise.



Question 4

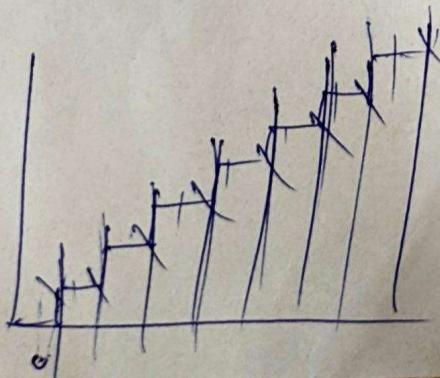
(2 Marks)

Consider a $10\text{ k}\Omega$ resistor at room temperature (300 Kelvin). Find its RMS noise voltage over a range of (10 Hz, 1000 Hz)

Question 5

(3 Marks)

Consider a 3-bit ADC having a reference voltage of 8 V and power-supply voltage of 10 V. The DNL associated with the eight codes (in their increasing order) of this 3-bit ADC are specified as 0.2 V, 0.1 V, 0.2 V, -0.5 V, 1.2 V, -0.1 V, 0.2 V, -0.4 V. Compute its INL (in V)



Breaks Down
Year 2022

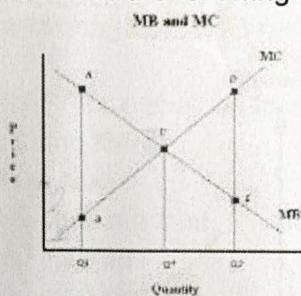
Indian Institute of Space Science and Technology
Department of Humanities

Quiz 2
(Institute Elective Course for B Tech final year students)
HS466 Space Economics and Policy

Date of Examination : 03.11.2022
Time of Examination : 9am to 10am Maximum Marks : 15

Choose the correct answer from the options. Please write your choice (a or b or c or d) and the corresponding answer in the answer sheet. All questions carry 0.5 marks each.

1. Which of the following are **not true** to the following Cost-Benefit Analysis graph?



- i. MB and MC are Marginal Benefit and Marginal Cost curves
- ii. Optimum point of the project is "B" because the Marginal Benefit is very high than that of marginal cost and the producer can maximise his total profit
- iii. Optimum point of the project is "C", where the marginal cost is equal to marginal benefit and the producer can maximise his total profit
- iv. At point 'D', Marginal Benefit is higher than Marginal Cost.
 - a. All are not true ✕
 - b. Only ii & iv are not true
 - c. Only i & iii are not true ✕
 - d. Only i, ii & iii are not true ✕

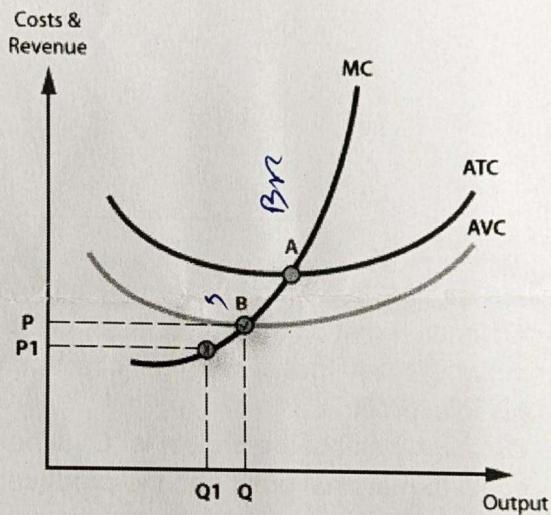
2. Which of the following represents benefit cost ratio?

- a. Present value of future benefits ÷ Net present value
- b. Present value of future benefits ÷ Present value of future costs
- c. Present value of future costs ÷ Present value of future benefits
- d. None of the above

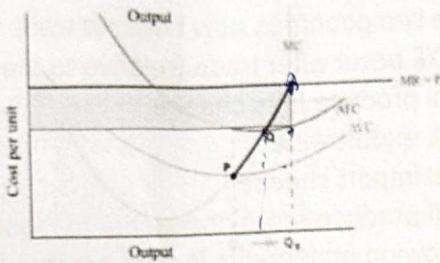
3. A cost-benefit analysis is performed to assess

- a. economic feasibility

- b. operational feasibility
 - c. technical feasibility
 - d. all of the above
4. which of the following are not included in a cost benefit analysis
- i. finding the direct and indirect cost of developing, implementing and running the system
 - ii. finding out the tangible and intangible benefit of the system
 - iii. finding the investment to be made in the system
 - iv. finding the profit which will accrue from the system
- a. iii and iv
 b. i and iv
 c. ii and iii
 d. i and ii
5. The point 'B' in the following diagram represents



- a. Shut-down point
 b. Break-even point
 c. Maximum profitability point
 d. None of the above
6. The area between the points 'P' and 'Q' in the following diagram represents



$$TC = VC + FC$$

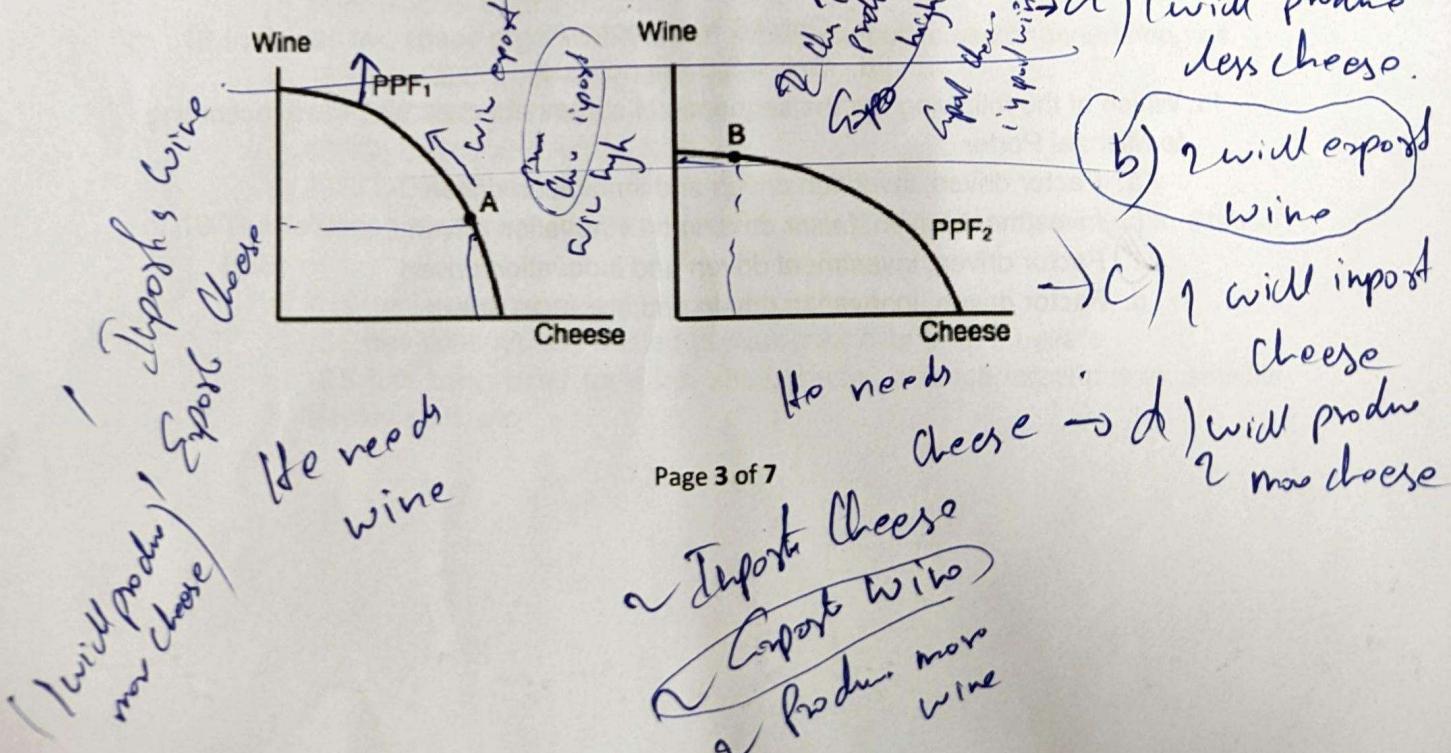
$$ATC = AVC + AFC$$

$$AVC = \frac{VC}{Q}$$

$ATC = \frac{FC}{Q} + AVC$

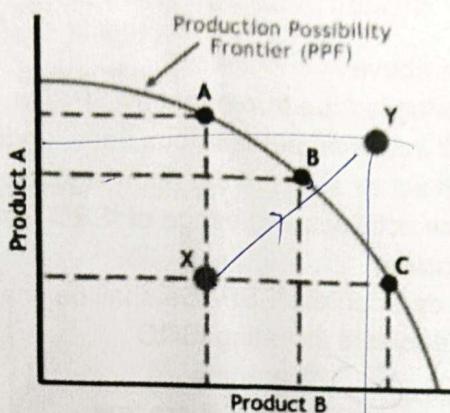
- a. Variable Cost
 b. Fixed Cost
 c. Total Cost
 d. None of the above
7. Which of the following is / are true about IN-SPACe
- i. It will act as an autonomous body, under DOS
 - ii. It will act as a one of the nodal agencies for enabling and regulating space activities and usage of ISRO facilities by non governmental agencies
 - iii. The decision of IN-SPACe shall be final and binding on all stakeholders including ISRO
- a. All are true
 b. Only i & iii are true
 c. Only i is true
 d. Only ii & iii are true
8. In the recent budgets of ISRO, which of the following has the largest share
- a. Space sciences
 - b. Space application
 - c. INSAT operations
 - d. Space technology

9. The diagram below illustrates the PPFs for two countries that produce wine and cheese. With no trade, country 1 produces at point A on its PPF and country 2 produces at point B.



Assume that the two countries now begin to trade with one another. Which of the following will NOT occur after trade (relative to the case with no trade).

- a. Country 1 will produce less cheese.
 - b. Country 2 will export wine
 - c. Country 1 will import cheese
 - d. Country 2 will produce more cheese.
10. Which of the following statements is / are not true regarding the following diagram



- i. Point 'X' is better combination than point 'A'
 - ii. Shifting of combination from 'B' to 'C' will enhance the production of Product A more than the production for Product B
 - iii. Shifting from combination 'X' to 'Y' is the highest level of production that this particular country can be achieved under existing conditions of resources and technology
 - iv. Point 'C' is better combination than 'A' when the country wanted to produce more of Product A.
 - a. All are not true
 - b. Only i, ii & iv are not true
 - c. Only i & iv are not true
 - d. Only ii & iii are not true
11. Which of the following are the sequence of stages of economic growth according to Michael Porter
- a. Factor driven, invention driven and innovation driven
 - b. Investment driven, factor driven and innovation driven
 - c. Factor driven, investment driven and innovation driven
 - d. Factor driven, innovation driven and invention driven.

12. Total number of women employees in ISRO / DOS is around
 a. 15%
b. 20%
c. 25%
d. 30%
13. Total national space budget of India for the financial year 2020-21
 a. Rs. 15,540 crore
b. Rs. 12,350 crore
 c. Rs. 13,700 crore
d. Rs. 11,520 crore
14. Free and open Earth Observation data policy has been adopted by USGS (Landsat) and EC-Copernicus(Sentinel) because
a. There are no commercial sale possibility of these data
b. Data acquisition, processing, archival and dissemination infrastructure and processes are not fully operational
c. Remote Sensing data do not bring economic benefit
 d. None of other three
15. The Outer Space Treaty (1967) does not provide for
 a) Liability of launching state for damage by their space objects
 b) National appropriation or claim on outer space or celestial bodies
c) Registration of space objects
d) Ban of placing weapons of mass destruction in space or celestial bodies
16. Regulation of communication between satellite and earth is carried out by
 a) National Space Agencies (e.g. NASA, ESA, JAXA, ISRO, etc)
 b) International Telecommunication Union (ITU)
c) Committee on Space Research (COSPAR)
d) UN Office of Outer Space (UNOOSA)
17. Wing Commander Rakesh Sharma orbited earth on the following space station
 a) Mir
b) Skylab
c) Salyut-7
 d) International Space Station
18. India has two space organisations and two space public sector undertaking as
a) ISRO, DRDO and NSIL, MIDHANI
b) ISRO, ESSO and Antrix, INSPACe
 c) ISRO, DSRO and Antrix, NSIL
d) ISRO, DRDO and Antri, HAL
19. The following statement is not correct in context of International Space Station (ISS)
a) It is the largest manmade structure in space
b) ISS has continuously hosted human crew over past 20 years
c) ISS has been used for earth photography, science experiments, satellite deployment, etc

- d) ISS is longest surviving manmade structure in space
20. International Space Station continuously communicates with earth due to
- Use of links in multiple frequencies (UHF, S, Ka band)
 - Use of distributed stations on ground
 - Availability of link via polar orbiting satellites
 - Availability of link via geosynchronous satellites
21. Outer Space Treaty (1967) provides for the following
- A rescue arrangement of astronauts in distress
 - A registry of space objects
 - Establishes a liability regime for damage caused by objects of a launching state
 - None of other three
22. UN Office of Outer Space Affairs performs the following function
- Secretariat to UN Committee on Peaceful Uses of Outer Space (UNCOPUOS)
 - Operates a Registry of Space Objects
 - Promote international space cooperation and capacity building
 - All of other three
23. The largest component in the total space economy can be attributed to
- Launch Vehicles
 - Satellite Manufacture
 - EO Satellite Data Sales
 - Satellite services
24. Which of the following statement is false about Indian space policy
- Indian Space Law is enacted by Parliament
 - Indian RS data policy does not prescribe limit for sale of high resolution data
 - Indian space policy guidelines do not permit private entities to own satellites
 - All of above
25. The following is India's international space cooperation contribution
- UNNATI Program
 - UN Centre for Space Science & Technology Education in Asia-Pacific
 - South Asian Satellite
 - All of the above
26. The following are India upstream space technology start-ups
- Agnikul, Bellatronix, Satsure
 - Bellatronix, Pixxel, Skyroot
 - Agnikul, Bellatronix, Skyroot
 - Satsearch, Satsure, Vesta Space
27. The following is not a component of Life Support System of International Space Station
- CO₂ removal, O₂ generation, urine recovery, Temp-RS Control
 - Waste recovery, trace contaminant control, Sabatier, CO₂ removal
 - CO₂ removal, O₂ generation, plant growth chamber, seed exposure

- d) O₂/N₂ control, waste recovery, Sabatier, Potable water
28. The following space instrument has the least number of countries ratification
- Outer Space Treaty
 - Moon Convention
 - Rescue Agreement
 - Registration Convention
29. Which of the following is / are **not correct** regarding the declared primary objective of the Indian Space Programme/Mission
- To achieve self-reliance in Space Technology
 - To execute programmes/missions for the socio-economic development of the country
 - To compete with space faring nations in showing the space capability
 - To demonstrate the technological capability to the developed nations
 - To showcase as a deterrent against external aggression
- Only i & ii are not correct
 - Only iii, iv & v are not correct
 - Only iii & iv are not correct
 - All are not correct
30. Two third share of global space economy generates in the form of
- Data sales
 - Broadband and Direct-to-Home television
 - Communication services
 - None of the above



Time: 1 hour

Max. marks: 15

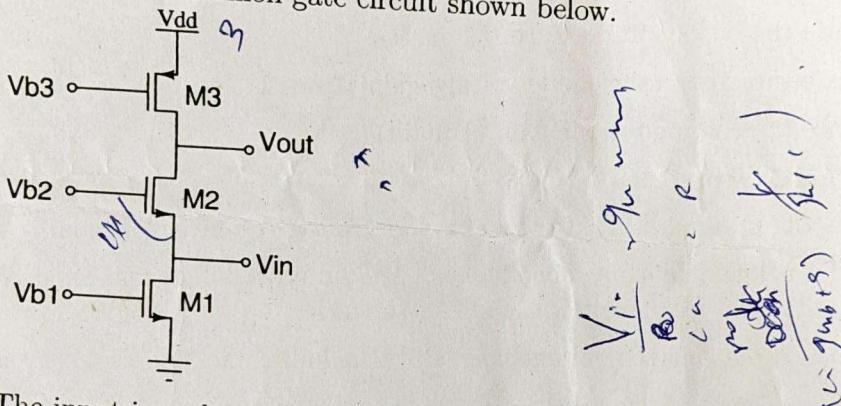
There is a choice between Qn2 & Qn 3. All other questions are compulsory.
 For all the questions, assume the following: $V_{DD} = 3V$, $\mu_n C_{ox} = 1\text{mA}/V^2$, $V_{THN} = 0.7V$,
 $\mu_p C_{ox} = 0.7\text{mA}/V^2$, $V_{THP} = -0.7V$, $\lambda_N = 0.1$, $\lambda_P = 0.05$.

You can assume square law model for MOSFET operation. Some formulae for use in your calculations are provided below: $I_D = \frac{\mu C_{ox}}{2} \frac{W}{L} (V_{GS} - V_{TH})^2$

$$g_m = \mu C_{ox} (W/L) (V_{GS} - V_{TH}) = \sqrt{2I_D \mu C_{ox} (W/L)} = \frac{2I_D}{(V_{GS} - V_{TH})}$$

$$r_0 = \frac{1}{\lambda I_D}$$

- Consider a CMOS inverter which is biased at the middle of the transition region, so that it functions as an analog amplifier. Derive the effective transconductance of this circuit. (2 marks)
- Consider the common gate circuit shown below.

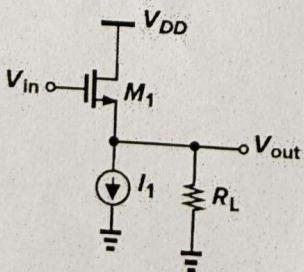


The input impedance is required to be 75Ω to match with cable TV.

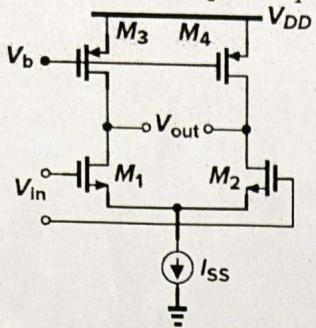
- Derive the input impedance, considering the r_0 and body effect. (2 marks)
- What is the current required to bias this amplifier if $V_{GS2} = 1V$, so that the input impedance is 75Ω ? ($g_{mb} = \eta g_m$, where $\eta = 0.25$). (2 marks)

OR

- Consider a common drain amplifier which is biased with a current source as shown below. The current source has an output impedance of R_L . Include r_0 , body effect in your derivations. You can neglect the capacitances of the transistor.



- (a) Derive the low frequency voltage gain. (2 marks)
- (b) Derive the output impedance. (2 marks)
4. Consider the OTA shown below. $I_{SS} = 0.5$ mA. $(\frac{W}{L})_{1,2} = 20/0.35$. The current source has an output impedance of 20 K Ω .



- (a) What is the transconductance of this OTA? (1 mark)
- (b) Calculate the output impedance. (1 mark)
- (c) Calculate the differential mode voltage gain (1 mark)
- (d) Calculate the common mode gain (1 mark)
- (e) Calculate CMRR (1 mark)
- (f) What is the minimum input common mode voltage required? (1 mark)
- (g) The OTA is loaded with a capacitance of 1pF on both differential arms. What is the unity gain frequency of the OTA? (1 mark)
- (h) Derive the input referred voltage noise PSD (including flicker noise). (2 marks)

SC/9B07

Indian Institute of Space Science and Technology
Department of Humanities

End Semester Examination
(Institute Elective Course for B Tech final year students)
HS466 Space Economics and Policy

Date of Examination : 28.11.2022

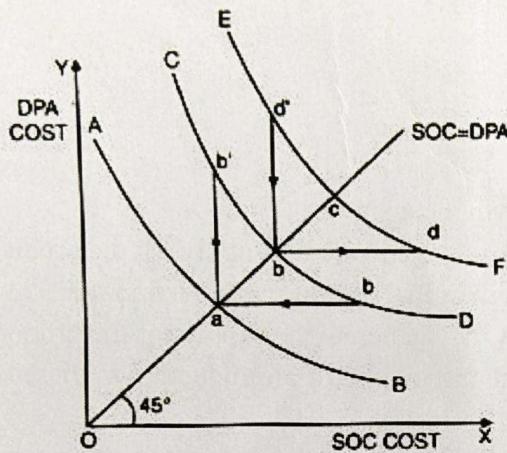
Time of Examination : 9.30 am to 12.30 pm

Maximum Marks : 50

Choose the correct answer from the options. Please write your choice (a or b or c or d) and the corresponding answer in the answer sheet. All questions carry 0.5 marks each.

1. The Unbalanced Growth is propounded by;
 - a. Ragnar Nurkse
 - b. H Leibenstein
 - c. A O Hirschman
 - d. R Roden
2. Complementaries in Unbalanced Growth means:
 - a. Growth of output of industry A may generate the supply for the products of B and C and also may reduce the marginal cost of production in these industries.
 - b. Growth of output of industry A may generate the supply for the products of B and C and also may increase the marginal cost of production in these industries.
 - c. Growth of output of industry A may generate the demand for the products of B and C and also may reduce the marginal cost of production in these industries.
 - d. None of the above
3. Which of the following is / are correct about 'Social Overhead Capital'
 - i. Social overhead capital comprises of those basic infrastructural facilities
 - ii. Without SOC, primary, secondary and tertiary activities cannot function
 - iii. This includes investment in final goods and services
 - iv. The investment on these projects create convergent series of investment
 - v. SOC investments are undertaken by Public agencies
 - a. All are correct
 - b. Only i, ii & iii are correct
 - c. Only i, ii & v are correct
 - d. Only i, ii & iv are correct
4. Investment in agriculture and industry can be categorised as;
 - a. Convergent series of investment
 - b. Divergent series of investment
 - c. Both convergent series and Divergent series of investment
 - d. Neither convergent nor Divergent series of investment
5. Assess the following statements about DPA in Unbalance Growth:

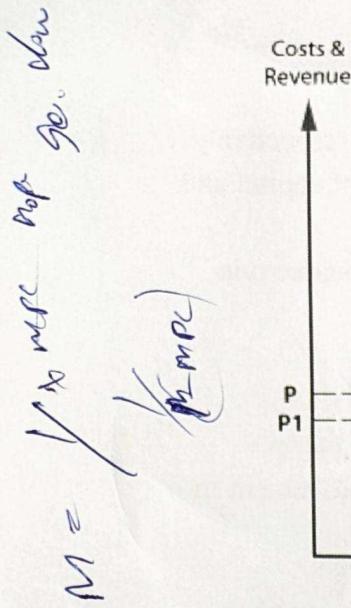
- i. Assertion: Directly Productive Activities are Divergent series of investment
- ii. Reason: Directly Productive Activities appropriates more economies than they create
 - a. Both 'i' & 'ii' are true and 'ii' explains 'i' clearly
 - b. Both 'i' & 'ii' are false
 - c. 'i' is false and 'ii' is true
 - d. 'i' is true and 'ii' is false
6. Which sequence in the following diagram represents 'Development via excess capacity of SOC'



- b abdc
- a. ab^1bd^1c
 - b. $abbdc$
 - c. $abdc$
 - d. abd^1c
7. Major reasons for the globalisation of space economy are
 - i. Global technology and finance linkages transformations
 - ii. Private funding of space based commercial projects
 - iii. Moving of space activities from the exclusive club of defence and aerospace industries to diverse capabilities of different countries
 - iv. Scope of combined development of space technology and its cost effectiveness led to high per unit profitability
 - a. All are correct
 - b. Only i, ii & iii are correct
 - c. Only i, ii & iv are correct
 - d. Only ii, iii & iv are correct
 8. Which of the following are true about the equation of Cobb-Douglas production function

$$f(L, K) = Y = AL^\alpha K^\beta,$$

- i. 'A' represents total factor productivity
ii. 'A' is a residual which often represents technical change
iii. α and β are the output elasticities of capital and labour, respectively
iv. Values of α and β are variables determined by the size of capital and labour.
v. It is a non-linear homogeneous production function of degree one
- (a) All are true
b. Only iv & v are true
c. Only i, ii & iii are true
d. Only ii, iii & iv are true
9. Which of the following is / are **true** about the competitiveness and improvement in productivity
- According to classical economists, improved economic competitiveness is achieved through capital investment
 - Classical economists argued that the productivity can be increased through technological change
 - Neo classical economists concentrated more on the importance of investment in national science and technology capabilities
 - Classical economists concentrated more on improvement in technology for increase in the growth and development of the country.
- a. All are true
(b) Only i & iii are true
c. Only ii & iv are true
d. Only i, ii & iii are true
10. Which of the following is **true** regarding Cost-Benefit Analysis?
- Optimum point of a project where the Marginal cost is equal to average cost and the producer can maximise his total profit
 - Optimum point of a project where the marginal cost is equal to marginal profit and the producer can maximise his total profit
 - Optimum point of a project where the total benefit is equal to average cost and the producer can maximise his total profit
 - None of the above
11. Which of the following are not included in a cost benefit analysis
- finding the direct and indirect cost of developing, implementing and running the system
 - finding out the tangible and intangible benefit of the system
 - finding the investment to be made in the system →
 - finding the profit which will accrue from the system
- a. iii and iv
b. i and iv ↙
c. ii and iii ↘
d. i and ii ↙
12. The point 'A' in the following diagram represents



- M = 1/mc*
- a. Shut-down point
 - b. Break-even point
 - c. Maximum profitability point
 - d. None of the above

13. Economists attribute 'shadow prices' to the project proposals because of

- i. Existence of under employment in the prevailing wage rate
- ii. Surplus funds at the existing interest rates
- iii. Scarcity of foreign exchange at the prevailing exchange rate
- iv. Reflecting the expected price and social costs
- v. The existence of fundamental disequilibria in developing countries
 - a. ii, iii & v
 - b. i, iii, & v
 - c. i, ii, & iv
 - d. All the above.

14. Lower Multiplier value in an economy can occur when

- i. Economy has excess capacity
- ii. low propensity to consume
- iii. Rising demand causes rising inflation
- iv. higher level of taxation
- v. decline interest rates
 - a. i, ii & iv
 - b. i, ii, iv & v
 - c. ii, iii, & iv
 - d. all the above

15. Shadow prices for exchange rates

- i. Scarcity of foreign exchange in developing countries will lead the equilibrium exchange rate is higher than its market exchange rate.
- ii. An artificial equilibrium is achieved in the balance of payments by fixing a higher shadow exchange rate than the official exchange rate.
 - a. Both 'i' and 'ii' are wrong

- b) Both 'i' and 'ii' are right and the 'ii' is the solution for the 'i'
- c. Both 'i' and 'ii' are right and the 'ii' is not the solution for the 'i'
- d. 'i' is wrong and 'ii' is right

16. Which of the following are **included** in the Construction Stage according to the evolutionary perspective of space technology development

- i. Launch Pads
- ii. Data services
- iii. Geospatial analysis
- iv. Weather forecasting
- v. Wind tunnel facility
 - a. All are included
 - b. i & v only
 - c. ii, iii & iv only ✓
 - d. i, iii & v only

17. Shadow prices

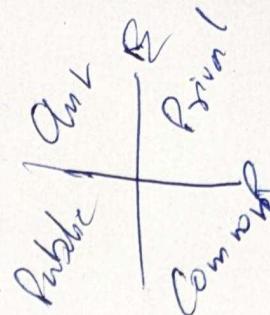
- i. Assertion: Actual market prices do not reflect social benefits and costs in developing countries ✓
- ii. Reason: Because the developing countries have relatively stable market prices and the market mechanism operates normally
 - a. Both assertion and reason are right and the reason perfectly explains the assertion
 - b. Both assertion and reason are right and the reason does not explain the assertion
 - c. Only assertion is right and the reason is wrong
 - d. Only the reason is right and the assertion is wrong.

18. Which of the following is / are **not correct** regarding the declared primary objective of the Indian Space Programme/Mission

- i. To achieve self-reliance in Space Technology
- ii. To execute programmes/missions for the socio-economic development of the country
- iii. To compete with space faring nations in showing the space capability
- iv. To demonstrate the technological capability to the developed nations
- v. To showcase as a deterrent against external aggression
 - a. Only i & ii are not correct
 - b. Only iii, iv & v are not correct
 - c. Only iii & iv are not correct
 - d. All are not correct

19. Two third share of global space economy generates in the form of

- a. Data sales
- b. Broadband and Direct-to-Home television
- c. Communication services
- d. None of the above



20. Which of the following is not correctly matching

- (a) Private goods are non-excludable and rival
- b. Club goods are excludable and non-rival
- c. Public goods are non-excludable and non-rival
- d. Common goods are non-excludable and rival

21. Externalities can be defined as

- a. Consumption benefits are non shared and can be limited to particular consumers
- b. Consumption benefits are shared and cannot be limited to particular consumers
- c. Consumption benefits are stopped and cannot be limited to government services
- d. None of the above

22. Analyse the following statements about Public Goods

- i. Public goods are provided publicly means that they are financed through the government budget
- ii. Public goods are produced directly by the government
 - a. Both 'i' & 'ii' are correct
 - b. Both 'i' & 'ii' are wrong
 - c. 'i' is wrong and 'ii' is right
 - (d) 'i' is right and 'ii' is wrong

23. Assertion (A): Exclusion is inappropriate in the case of public goods

Reason (R): Because their consumption is non-rival.

- a. Both A & R are right and R explains A
- b. Both A & R are wrong
- (c) Both A & R are right but R does not explain A
- d. A is right and R is wrong

24. Which one of the following statement is not true regarding Public Goods

- a. The aggregate demand for a public good is the sum of marginal benefits to all persons at total quantity of the good provided
- b. The economy's marginal benefit curve (demand curve) for a public good is thus the vertical sum all individual's marginal benefit curves.
- (c) The optimal quantity of the public good occurs where MB (society's marginal benefit) equals MC (provider's marginal cost), or where the two curves intersect.
- d. The market demand curve for public goods gives the price society is willing to pay for a given quantity.

25. Which one of the following statements is not true about Bozeman's Theory of Degree of Publicness?

- a. All organizations are public to one degree or another and that publicness is therefore a matter of degree
- b. Organizations can be considered to be more or less 'public' and more or less 'private.'
- c. All organizations are subject to political authority to a greater or lesser extent

d. Organizations with high political authority have a high degree of control over their financial decisions; those with low political authority are subject to tight government financial control

26. Which of the following is not true regarding 'Marginal Efficiency of Capital'

- i. It is a unique rate of discount, which would make the present value of the current net returns from a capital asset just equal to its production cost
- ii. The calculation accommodates the rise in the supply price of the asset periodically.
- iii. The term originates with classical economists and is also known as the external rate of return
 - a. All are not true
 - b. Only iii is not true
 - c. Only i & iii are not true
 - d. Only ii is not true

27. MEC is different from MEI because

- a. What is true of an individual firm is true for the economy as a whole
- b. Decline in Interest rate will lead to the decline in investment and demand for capital goods
- c. Decline in interest rate will increases the demand for capital goods and thereby decrease in its prices
- d. None of the above

28. The Satellite Telecommunication Experimental Project (STEP) was introduced during the period

- a. 1975-78
- b. 1977-79
- c. 1971-74
- d. 1973- 75

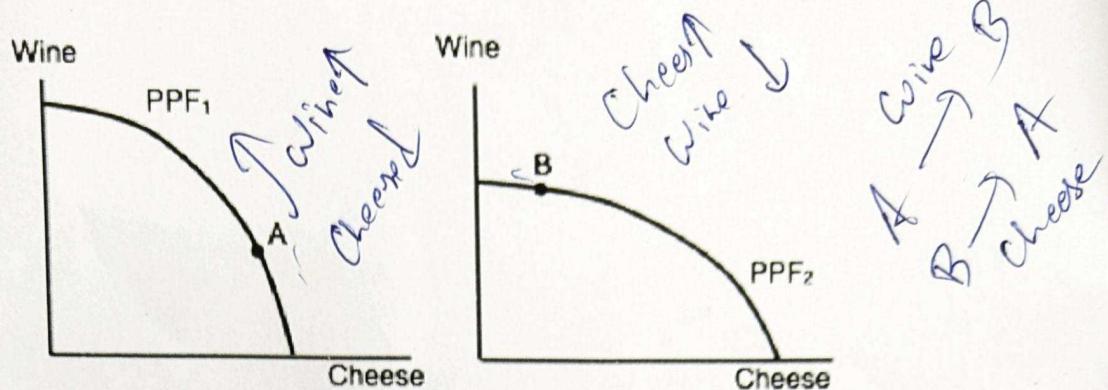
29. Which of the following is / are true about IN-SPACe

- i. It will act as an autonomous body, under DOS
- ii. It will act as a one of the nodal agencies for enabling and regulating space activities and usage of ISRO facilities by non governmental agencies
- iii. The decision of IN-SPACe shall be final and binding on all stakeholders including ISRO
 - a. All are true
 - b. Only i & iii are true
 - c. Only i is true
 - d. Only ii & iii are true

30. In the recent budgets of ISRO, which of the following has the largest share

- a. Space sciences
- b. Space application
- c. INSAT operations
- d. Space technology

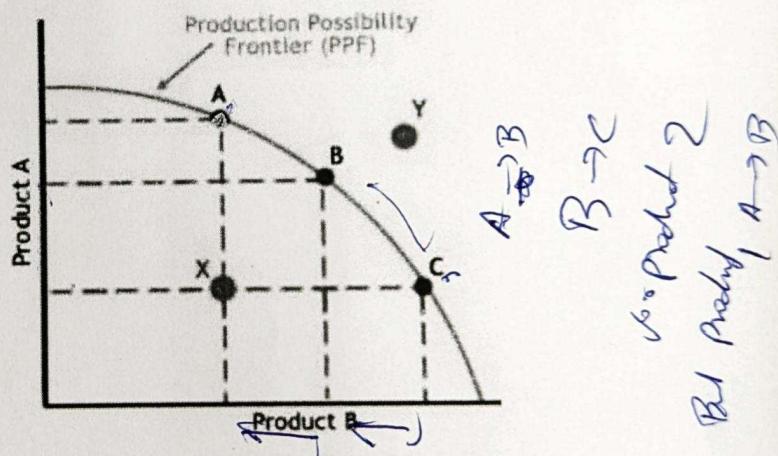
31. The diagram below illustrates the PPFs for two countries that produce wine and cheese. With no trade, country 1 produces at point A on its PPF and country 2 produces at point B.



Assume that the two countries now begin to trade with one another. Which of the following will NOT occur after trade (relative to the case with no trade).

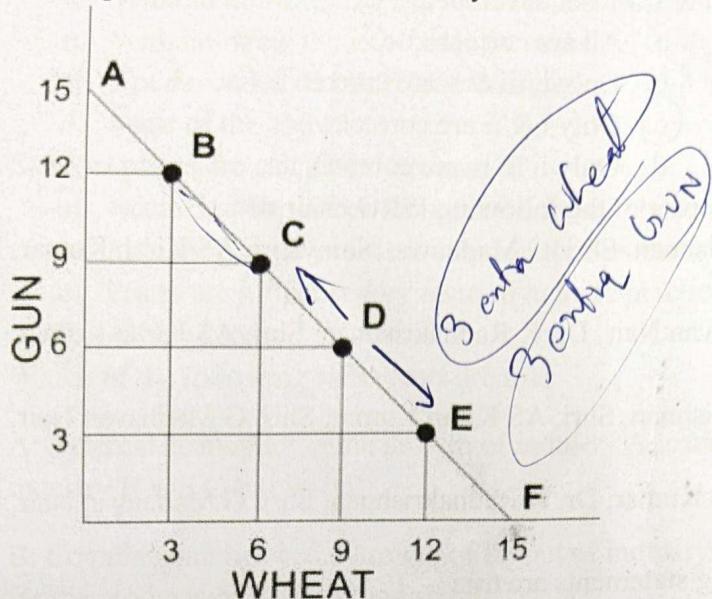
- a. Country 1 will produce less cheese.
- b. Country 2 will export wine
- c. Country 1 will import cheese
- d. Country 2 will produce more cheese.

32. Which of the following statements is / are not true regarding the following diagram



- i. Point 'X' is better combination than point 'A'
- ii. Shifting of combination from 'B' to 'C' will enhance the production of Product A more than the production for Product B
- iii. Shifting from combination 'X' to 'Y' is the highest level of production that this particular country can be achieved under existing conditions of resources and technology
- iv. Point 'C' is better combination than 'A' when the country wanted to produce more of Product A.
 - a. All are not true
 - b. Only i, ii & iv are not true
 - c. Only i & iv are not true
 - d. Only ii & iii are not true

33. A straight line Production Possibility curve like the following one will have



- a. Increasing opportunity cost
- b. Decreasing opportunity cost
- c. Constant opportunity cost
- d. None of the above

34. New Space India Limited is a

- a. Private Limited Company
- b. Public Sector Undertaking
- c. Public Private Participation Agency
- d. None of the above

35. Which one of the following is not a Space Insurance Company

- a. AXA-XL
- b. Munich-RE
- c. XL Catlin
- d. Zurich Insurance

36. Which is the largest component of space craft value by market

- a. Commercial
- b. Civil Government
- c. Military
- d. Human Space Flight

37. Which one of the following represents the value of Multiplier

- a. $M = 1 / (1 - MPC)$
- b. ~~$M = 1 / (1 - MPS)$~~
- c. $M = 1 / (MPC - 1)$
- d. None of the above

38. Experimental Phase of Indian Space Program

- i. Rohini satellites, Apple, SLV-3
- ii. Beginning of INSAT series production

- iii. STEP & SITE Experiments
- iv. Beginning of GSLV
- v. Edusat & Cartosat developed
 - a. All are correct
 - b. Only i, iii & v are correct
 - c. Only i & ii are correct
 - d. Only ii & iv are correct.

39. Correct chronological order of the following ISRO chairmen

- a. Dr. K Radhakrishnan, Shri. G Madhavan Nair, Shri. AS Kiran Kumar, Dr. K Sivan
- b. Shri. G Madhavan Nair, Dr. K Radhakrishnan, Shri. AS Kiran Kumar, Dr. K Sivan
- c. Dr. K Radhakrishnan, Shri. AS Kiran Kumar, Shri. G Madhavan Nair, Dr. K Sivan
- d. Shri. AS Kiran Kumar, Dr. K Radhakrishnan, Shri. G Madhavan Nair, Dr. K Sivan

40. Which of the following statements are true

Assertion (A): Market mechanism is not ideal for providing private goods

Reason (R) : Increasing marginal cost and perfect competition

- a. Both A and R are true, and R perfectly explains A
- b. Both A and R are false
- c. A is only right and R is wrong
- d. R is only right and A is wrong.

41. Which of the following statements are true

Assertion (A) : Market Demand curve for a public good is downward sloping

Reason (R) : It is due to law of diminishing Marginal Cost

- a. Both A and R are true, and R perfectly explains A
- b. Both A and R are false
- c. R is only right, and A is wrong.
- d. A is only right, and R is wrong

42. According to Bozman's concept of 'Degree of Publicness'

Assertion (A) : Organizations with high economic authority have a high degree of control over their financial decisions

Reason (R) : Organizations with low economic authority are subject to tight government financial control

- a. Both A and R are true, and R is the reason of A
- b. Both A and R are true, and R is not the reason of A
- c. Both A and R are false.
- d. A is only right, and R is wrong

43. Expected utility theory is used as a tool for analyzing situations where individuals must make a decision

- a. Without knowing the expected outcomes
- b. With knowing the expected outcomes
- c. Not depended on expected outcomes
- d. None of the above

44. Shadow prices are calculated because of

- a. Actual market prices do not reflect social benefits and costs
- b. Influence of government on pricing of products
- c. Prices are influenced by restrictive trade practices or monopolies
- d. All the above.

45. Which of the following statements are true

A: External economies is the growth of industry A leads to or stimulates the growth of industry B and C and so on

B: Complementaries is the growth of output of industry A may generate the demand for the products of B and C and so on

- a. Both A and B are false
- b. Both A and B are true
- c. A is true and B is false
- d. A is false and B is true

46. Examine the following statements

A: Directly Productive Activities (DPA) are called divergent series of investment

B: DPA investments are undertaken by private entrepreneurs

- i. Both A and B are True
- ii. Only A is true and B is false
- iii. Only B is true and A is false
- iv. Both A and B are false

47. In which year the Space Science and Technology Centre (SSTC) established at Thumba

- a. 1962
- b. 1963
- c. 1965
- d. 1967

48. Analyse the following statements and choose the right answer

- i. About 60% of the budget of ISRO has spent during the exploratory and commercial phase
- ii. About 15% of the budget of ISRO has spent during the experimental phase

- iii. About 10% of the budget of ISRO has spent during the Proof of concept phase
- iv. About 70% of the budget of ISRO has spend during the exploratory and commercial phase
 - a. i, & ii are correct
 - b. i & iii are correct
 - c. ii & iv are correct
 - d. all are incorrect

49. Which one of the following ISRO chairman has a master degree in English Literature

- a. Dr. Vikram Sarabhai
- b. Prof. Satish Dhawan
- c. Prof. U R Rao
- d. Dr. Kasturi Rangan

50. Analyse the following statements about Solow Growth Model

Assertion (A): Solow Growth Model is an exogenous growth model

Reason (R): Population growth is assumed to be exogenous and measured as residual.

- a. Both A and R are correct, and R explain the A
- b. Both A and R are incorrect
- c. A is correct and R is false
- d. Both A and R are correct and R does not explain the A

51. Which of the following are the properties of Aggregate Production Function

- i. Marginal products of inputs are positive
- ii. The increase in output from adding more inputs is lower when we have more of a factor
- iii. Increase in technology increases marginal product of capital
 - a. All are correct
 - b. Only i and iii are correct
 - c. Only i and ii are correct
 - d. Only ii and iii are correct

52. Which of the following statements are true regarding foreign launches of Indian satellites

- i. Bhaskara-2 launched from Russia
- ii. GSAT-7 launched form USA
- iii. INSAT-2A launched from France
- iv. IRS-1C launched from Russia
 - a. All are true
 - b. Only i, iii and iv are true
 - c. Only i, ii and iv are true
 - d. Only i, and iv are true

53. Which of the following vehicles launched the highest number of satellites in a single mission.

- a. PSLV-C46

- b. PSLV-C38
- c. PSLV-C37
- d. PSLV-C51

54. Purchase of a technology / machine will take place when the

- a. MEC > Interest
- b. MEC < Interest
- c. MEC = Interest
- d. None of the above

55. Cobb-Douglas production function

A: models the relationship between production output and production inputs (factors)

B: It is used to calculate ratios of outputs to one another for efficient production and to estimate technological change in production methods.

0.3% *Growth of
GDP*
1.0% *Interest*

- a. Both A and B are correct
- b. A is correct and B is wrong
- c. A is wrong and B is correct
- d. Both A and B are wrong.

56. ISRO Budget as percentage of GDP is around

- a. 0.5%
- b. 0.05% *→*
- c. 0.005%
- d. None of the above

57. Global Space Economy

- i. The global space economy continued to expand in 2021 to reach \$469 billion.
- ii. This record high also had the largest growth rate since 2014, growing 9% from a revised 2020 total \$431 billion.

- a. Both i & ii are correct
- b. i, is correct and ii is wrong
- c. ii is correct and i is wrong
- d. Both i & ii are wrong

58. Major share of global space economy from the following category is

- a. Commercial revenue
- b. Government spending
- c. Infrastructure and support services
- d. US Space budget

59. Out of 1,730 payloads launched in 2021, 90% were launched into

- a. GEO
- b. MEO
- c. LEO
- d. All the above

60. Name of the space agency established by Zimbabwe in 2018

- a. ZINGSA
- b. ZNGSA
- c. ZSIGA

d. SAZ

61. What is SirillsXM?

- a. Global Insurance company
- b. Global satellite telephone provider
- c. Global Satellite radio provider
- d. Global space tourism company

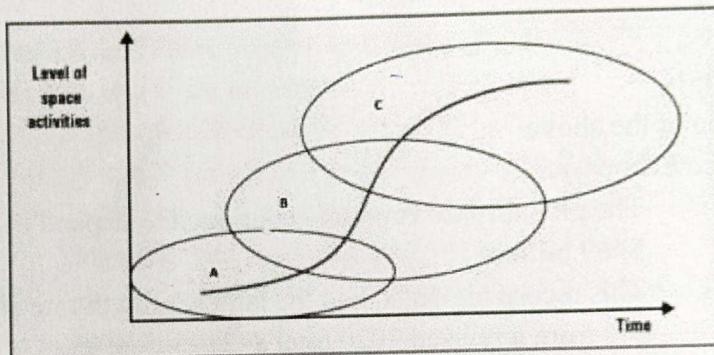
62. Proposed Headquarters of African Space Agency

- a. Nairobi
- b. Abuja
- c. Egypt
- d. Cape Town

63. ASI is the space agency of which country

- a. Australia
- b. Italy
- c. Argentina
- d. Iceland

64. Identify A, B and C in the following diagram



- a. Intensity, Readiness, Impacts

- b. Readiness, Intensity, Impacts
- c. Impact, Readiness, Intensity
- d. Readiness, Impacts, Intensity

65. Percentage of Govt spending in Global Space Economy

- a. 30%
- b. 42%
- c. 18%
- d. 23%

66. Tragedy of Commons is the feature of which type of goods

- a. Public goods
- b. Common goods
- c. Club goods
- d. Private goods

67. Public goods are

- a. Public produced and public provided
- b. Private produced and Public provided

Ques 67

- c. Public produced and private provided
 - d. All the above
68. Aggregate benefit of NASA R&D has been measured by using
- a. Solow Growth model
 - b. Midwest Research Institute Model
 - c. Consumer surplus model
 - d. None of the above
69. SAPPHIRE satellite was built by
- a. Germany
 - b. Brazil
 - c. Canada
 - d. Denmark
70. Indian space research started by launching Nike Apache rocket on
- a. 21st Nov 1963
 - b. 21st Nov 1962
 - c. 21st Nov 1964
 - d. 21st Nov 1961
71. Resource extraction from celestial bodies has technological challenges as well as
- a) No legal and policy challenge
 - b) Majority of national laws allow space mining
 - c) All nations have signed and ratified treaties prohibiting extraction of resources
 - d) Challenge of negotiating balance between "non appropriation" and nations right to "access and use" space
72. Humans travel in space has challenges but
- a) Effects on human body are understood and fully reversible
 - b) Space craft and space suit provide safety from all hazards
 - c) Space radiation or its high energy particles can penetrate both spacecraft and space suit
 - d) All of the above
73. Spurt in Space debris have been observed due to
- a) Space shuttle flights
 - b) Rocket parts and spacecrafts that are no longer in use
 - c) Use of antisatellite technology
 - d) Extreme space weather events
74. INSPACe has been established in Dept of Space to
- a) Support ANTRIX in marketing ISRO technology
 - b) Support HSFC in Indian human spaceflight program
 - c) Provide level field to private entities engaged in space activities in India
 - d) None of the above
75. Weightlessness effects on human body include
- a) Osteopenia and muscular atrophy
 - b) Fluid redistribution causing moon face
 - c) Slowing of production of RBC and cardiovascular system
 - d) All of the above
76. International Space Station can communicate fully with earth due to

- a) Use of links in multiple frequencies (UHF, S, Ka band)
 - b) Use of distributed stations on ground
 - c) Availability of link via polar orbiting satellites
 - d) Availability of link via geosynchronous satellites
77. The following space technology remains to be demonstrated by ISRO
- a) In situ analysis of celestial body surface chemistry
 - b) Reentry of space craft through earth's atmosphere
 - c) Orbiting a solar plant
 - d) In-space rendezvous of two spacecraft
78. The following Indian space startup would have its satellite launched by ISRO in early 2021
- a) Agnikul
 - b) Bellatrix
 - c) Pixxel
 - d) Satsure
79. RLV-TD project of ISRO aims to
- a) Retrieve first stage rocket for reuse
 - b) Develop cryogenic technology
 - c) Develop winged spacecraft for multiple operations
 - d) Develop an interplanetary transportation system
80. This is not a correct description of NISAR (NASA-ISRO) SAR
- a. NISAR is a L and S band SAR
 - b. NISAR is a C and X band SAR
 - c. NISAR launch and spacecraft bus will be provided by ISRO
 - d. NISAR has a JPL/NASA designed large unfurlable antenna
81. Indian launch vehicle with highest mass lifting capacity to GTO is
- a. Satellite Launch Vehicle (SLV)
 - b. Geostationary Satellite Launch Vehicle (GSLV)
 - c. GSLV-Mk III
 - d. Polar Satellite Launch Vehicle (PSLV)
82. The following ISRO mission is not a technology demonstrator for Gaganyaan Mission
- a) Pad Abort Test
 - b) Space Recovery Experiment (SRE)
 - c) Reusable Launch Vehicle-Technology Demonstrator (RLV-TD)
 - d) LVM-CARE
83. The following navigation satellite constellation uses least number of satellites
- a) IRNSS
 - b) Galileo
 - c) Beidou
 - d) GLONASS
84. The Outer Space Treaty (1967) does not provide for
- a) Liability of launching state for damage by their space objects
 - b) National appropriation or claim on outer space or celestial bodies
 - c) Registration of space objects
 - d) Ban of placing weapons of mass destruction in space or celestial bodies
85. Polar Satellite Launch Vehicle is used to launch of

- (a) Satellites in low earth sun-synchronous orbits
 - (b) Satellites in equatorial as well as multiple orbits
 - (c) Satellites with lower mass to Geostationary Transfer Orbits (GTO)
 - (d) All of the above
86. This is not a communication satellite mission of ISRO/India
- (e) Indian National Satellite System (INSAT)
 - (f) Geostationary Satellite (GSAT)
 - (g) Ariane Passenger Payload Experiment (APPLE)
 - (h) Bhaskara
87. Global Space economic benefits and impacts are difficult to quantify because
- a. Conceptual difficulty in defining boundary of space economy for enterprise simultaneously involved in non-space earth activities
 - b. Difficult to quantify monetary value of indirect effects
 - c. Information on military space spending as well as revenue by all enterprise relevant to space is not openly available
 - (d) All of other three
88. Free and open Earth Observation data policy has been adopted by USGS (Landsat) and EC-Copernicus(Sentinel) because
- a. There are no commercial sale possibility of these data
 - b. Data acquisition, processing, archival and dissemination infrastructure and processes are not fully operational
 - c. Remote Sensing data do not bring economic benefit
 - d. None of other three
89. Regulation of communication between satellite and earth is carried out by
- a) National Space Agencies (e.g. NASA, ESA, JAXA, ISRO, etc)
 - (b) International Telecommunication Union (ITU)
 - c) Committee on Space Research (COSPAR)
 - d) UN Office of Outer Space (UNOOSA)
90. The following is not a correct description of ISRO Small Satellite Launch Vehicle (SSLV)
- a) SSLV is a 3 stage vehicle
 - b) SSLV has all stages with solid motor
 - c) SSLV has 3rd stage cryogenic engine
 - d) SSLV will launch upto 500kg satellites in 500 km orbit
91. The most appropriate common thread among the missions Stardust, Hayabusa and Rosetta is
- a) They all are interplanetary missions
 - b) They all had similar mission goals
 - c) They all were flyby missions for asteroids/comets
 - (d) They all landed on a asteroid/comet
92. Search for water on asteroids has potential applications for
- a) Source of rocket propellant and radiation shielding
 - b) Source of water for plant growth and breathable air
 - (c) All of above

- d) None of the above
93. Laser have an edge over microwave for wireless power transmission following parameters
- Lower transmit and receiving aperture diameter
 - Higher demonstrated conversion efficiency for transmit and receive
 - Insensitive to weather
 - None of the above
94. Space weather interacts with satellites in the following ways
- Solar array arc discharge and lower power due to radiation damage
 - Spacecraft components become radioactive
 - Single event effects on microelectronics
 - All of the above
95. Which is appropriate statement for space vehicle launch
- Launch vehicles have minimal impact over atmosphere
 - Launch vehicle emissions for aerosol and alumina can cause stratosphere cooling like volcanoes
 - Launch vehicle emissions can result in stratosphere warming
 - None of the above
96. The following is not a correct description of Vikram Sarabhai
- Sarabhai was educated at Ahmedabad, IISc Bangalore and Cambridge University
 - Sarabhai established more than two dozen institutions/ organizations
 - Sarabhai research interest was study of cosmic rays
 - Sarabhai was not associated with Atomic Energy program of India
97. The following statement is not correct in context of International Space Station (ISS)
- It is the largest manmade structure in space
 - ISS has continuously hosted human crew over past 20 years
 - ISS has been used for earth photography, science experiments, satellite deployment, etc
 - ISS is longest surviving manmade structure in space
98. Outer space treaty, rescue agreement, moon agreement and Liability convention – match the year of inception
- 1967, 1968, 1984, 1972
 - 1968, 1967, 1972, 1984
 - 1967, 1972, 1968, 1984
 - Not matching any of the above years.
99. Which of the following are true about Indian Defense space program
- NSA Shivshankar Menon set up task force in July 2011 to review recommendations of Kargil Review Committee
 - Defense Space Agency (DSA) announced by PM (Narendra Modi) at Combined Commander's Conference at Jodhpur Air Force Station on 28 Sep 2018
 - June 2019, Cabinet approved establishment of Defense Space Research Organisation (DSRO) as the scientific organization under DSA for developing required space-warfare technologies

- d. All the above are true
100. Which of the following is not true about commercial EO programs
- a. Landsat was first civilian EO satellite. Earlier were all military missions
 - b. First commercial EO satellite was SPOT by French-European consortium SPOTIMAGE launched in 1986
 - c. Land Remote Sensing Policy Act of 1992 (USA) Permitted private companies to launch and operate EO satellites
 - d. Landsat program saw many twists and turns leading to adoption of fully open data policy in 1997 by USGS

INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY

Date: 06 Dec., 2022

Time: 3 Hours

Total Marks: 100

No. of Students: 47

End-Sem

Dept. of Avionics

Sub. No. AV491, Sub. Name: Advanced Sensors and Interface Electronics

Answer all questions in Part A. Answer any 6 of 7 questions in Part B.

Part A

(10 Marks)

Fill the blanks.

- (1) DNL specification is important for _____ application.
- (2) Input Resolution of a 4-bit unipolar Flash ADC (reference voltage = 8 V) is _____.
- (3) The SNDR of an ADC closely follows its _____.
- (4) An application of Negative Resistance Converter is _____.
- (5) Two merits of GMR technology over Hall Effect are _____ and _____.
- (6) A 1 kΩ resistor can be realized using a switched capacitor circuit with _____ valued-capacitor and clock signal of 100 kHz frequency.
- (7) The output of a GMR-based angle sensor varies as a _____ function of the input angular position.
- (8) Resting potential of a human cell is around _____.
- (9) Minimum number of Hall sensors required in anti-differential current probe is _____.

Part B (answer any 6 of 7 questions)

Question 1

(3 + 5 + 7 = 15 Marks)

- (a) Draw a neat labelled schematic showing the electrode and amplifier connections in a unipolar chest ECG.
- (b) Consider a typical lead-1 ECG system. It is given that the arm-electrode impedances are 120 kΩ and 100 kΩ, and ground-electrode impedance is 100 kΩ. Assume the availability of a 3-opamp instrumentation amplifier (IA) of CMRR = ∞ . The differential ECG signal and common-mode signal at the input of the IA is, respectively, around 10 µV and 10 mV.

What should be the minimum input resistance of the IA that will ensure the SNR of 40 dB at its output.

- (c) Draw the schematic of a right-leg driver circuit for the system in (b). Suppose a set of ideal operational amplifiers, nine 20 kΩ resistors, and two 1 MΩ resistors as well as +/- 15V dual power supplies are available to implement the IA and driver-leg driver circuit. Then, determine the
 - (i) factor by which the common-mode signal from human body can decrease, for a given displacement current.
 - (ii) displacement-current in case the human subject gets exposed to a high common mode voltage.

Question 2

(4 + 5 + 6 = 15 Marks)

- (a) Fluid velocity (v) in a pipe was measured using an ultrasonic flowmeter set-up as shown in Fig. 1. Following procedure was followed during the experimentation.

(1) Piezoelectric crystals, A and B were configured, respectively, as transmitter and receiver & transit time was noted.

(2) The roles of crystal A and B were interchanged and transit time was again noted.

(3) Difference of transit times noted in above steps was 75 µs.

Using the above data, calculate the velocity of the fluid. Assume that the velocity of the sound in the fluid is 500 m/s. (you can make suitable assumptions to simplify the calculations.)

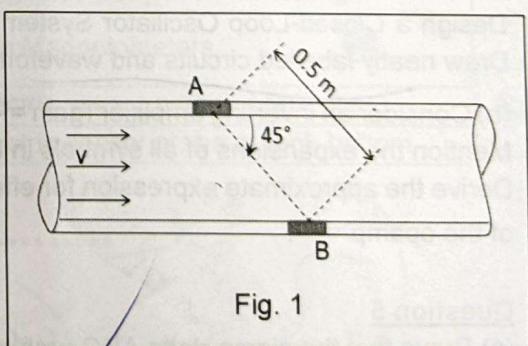


Fig. 1

- (b) Draw the structure and equivalent circuit of a capacitive sensor probe that can be used for non-contact measurement of AC line voltage. Show that an analog signal conditioner, coupled with an FFT approach, can be used with the sensor probe to estimate the unknown voltage, without the effect of unwanted capacitances.

$$\begin{aligned}
 & 100 \times 10^3 \times 10^3 \\
 & = 10^8
 \end{aligned}$$

(c) In the circuit (Fig. 2), the switch SW2 will be at position-A if the signal, v_c = HIGH and at position B, if v_c = LOW. Determine the output, V_o when the SW1 is wired to position-A (as shown in the figure). Also, compute the output, V_o when SW1 is shifted to position-B.

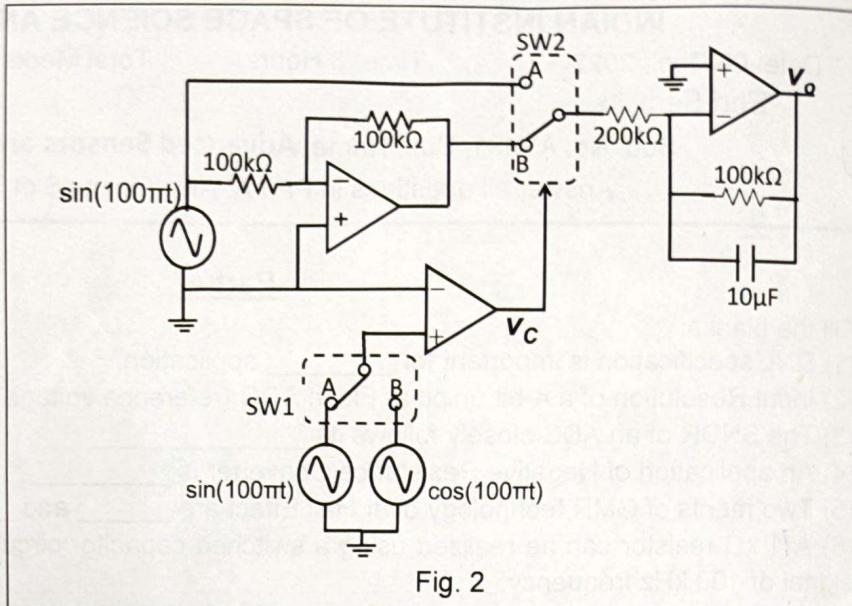


Fig. 2

Question 3

(8 + 7 = 15 Marks)

(a) A piezoelectric crystal, acting as a force sensor, is connected using a cable to a voltmeter of purely resistive impedance of $10 \text{ M}\Omega$. Crystal and Cable specifications are tabulated next:

Crystal specifications:	
Charge sensitivity to force = 2 pC N^{-1}	
Capacitance = 95 pF	
Natural frequency = 40 kHz	
Damping ratio = 0.01	
Cable specifications:	
Capacitance = 5 pF	
Resistance = $1 \text{ G}\Omega$	

- (i) Calculate the transfer function of the force-sensor system, considering all of the above parameters.
- (ii) Assume that the piezoelectric crystal is connected to a charge amplifier with feedback capacitance $C_F = 1000 \text{ pF}$ and feedback resistance $R_F = 100 \text{ M}\Omega$. Sketch the frequency response characteristics of the modified system. Is this system suitable for thrust measurement frequency of an engine, where thrust varies as a pulse wave of period 10 ms. Give reason.

b) Design an efficient capacitive measurement scheme for level measurement of a conductive liquid present in a plastic (cylindrical) tank. With the help of equivalent circuits and diagrams of the electrodes used in the tank, explain how your measurement scheme can nullify the effect of undesired parameters.

Question 4

(7 + 8 = 15 Marks)

(a) A piezoelectric crystal has an effective mass of 0.1 kg , stiffness of 10^{10} N m^{-1} and damping constant 200 Ns m^{-1} . Electrical capacitance of the crystal is 1000 pF and the charge to force sensitivity is $2 \times 10^{-10} \text{ C N}^{-1}$. Calculate the series and parallel resonant frequencies of the crystal.

Design a Closed-Loop Oscillator System which will oscillate at the series resonant frequency of the crystal. Draw neatly labelled circuits and waveforms to explain your design methodology.

(b) Consider an inverting amplifier (gain = -1) realized using two equal resistors. Draw its noise equivalent model. Mention the expansions of all symbols in the noise model.

Derive the approximate expression for effective output spectral density of the amplifier. Assume open-loop-gain of the opamp = ∞ .

Question 5

(4 + 4 + 3 + 4 = 15 Marks)

- (a) Prove that the sigma-delta ADC architecture provides noise shaping feature.
- (b) A half-rectified sine-wave of 1 V amplitude is applied to a unipolar 10-bit ADC whose reference voltage (V_R) is 5 V . Find the SNR of the ADC for this case.
- (c) Draw the schematic of a ring-core flux gate magnetometer. Label its important parts.
- (d) Find the equivalent capacitance (C_{EQ}) at the node A (see Fig. 3) with respect to ground.

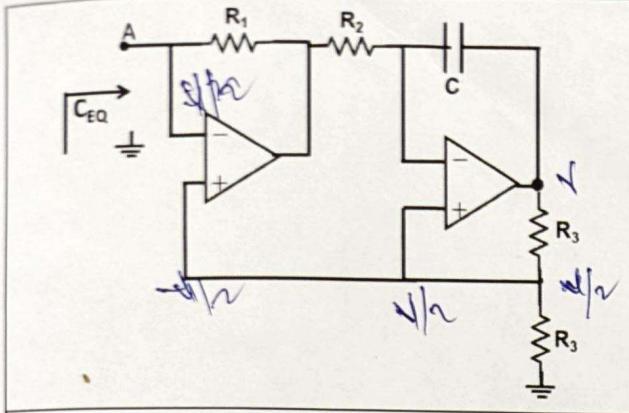


Fig. 3

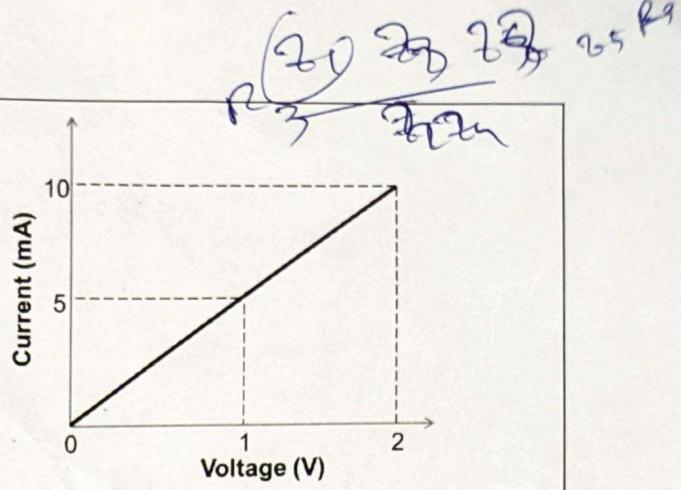


Fig. 4

Question 6

(4 + 4 + 7 = 15 Marks)

- (a) Discuss how eddy-current principle can be used for non-destructive evaluation of metallic plates.
(b) The approximate I-V characteristic of a diode is shown in Fig. 4. Draw its noise-equivalent model. Find the noise voltage across its terminals for a forward current of 5 mA and noise-bandwidth of 100 Hz.
(c) A push-pull type capacitive sensor is given. Design a signal conditioning circuit such that following properties are obeyed.

Circuit output should be independent of the stray capacitances present in the sensor system and should have zero-offset, and be independent of the nominal sensor capacitance.

Explain, with the help of suitable waveforms, on how your circuit provides the aforesaid features.

Question 7

(3 + 12 = 15 Marks)

- (a) Write the transfer function of a second-order all pass filter (APF). Draw the circuit diagram of APF using Universal Active Filter approach.

(b) The following table lists a number of sensing problems and some measurement electronics schemes. Choose the most optimal measurement scheme (from second column) for each sensing problem (given in first column). Briefly explain, in few sentences, the reason for your choice. Illustrative figures can be used.

Sensing Problem	Measurement Electronics Techniques
1. Conductivity Measurement of Metals	A. Twin Hall Effect Sensing
2. Flow-rate measurement of clean fluids	B. Low frequency Eddy current Testing
3. Flow-rate measurement of impure fluids	C. Doppler Effect Ultrasonic Flowmeters
4. Non-Destructive Sub-surface Evaluation of Metallic Plates	D. Transit time Ultrasonic Flowmeters
5. Geophysical Surveys	E. High-frequency Eddy current Testing
6. Non-invasive arrangement of measurement of water level in a tank.	F. Flux-gate Magnetometers
	G. Piezoelectric sensor probe at tank-top
	H. Piezoelectric sensor probe at tank-bottom