About GATE

Graduate Aptitude Test in Engineering (GATE) is a national examination conducted jointly by the Indian Institute of Science (IISc), Bengaluru and the seven Indian Institutes of Technology (at Bombay, Delhi, Guwahati, Kanpur, Kharagpur, Madras and Roorkee) on behalf of the National Coordination Board (NCB)-GATE, Department of Higher Education, Ministry of Education (MoE), Government of India.

Qualifying in GATE is a mandatory requirement for seeking admission and/or financial assistance to: (i) Master's programs and direct Doctoral programs in Engineering/ Technology/ Architecture and (ii) Doctoral programs in relevant branches of Arts and Science, in the institutions supported by the MoE and other Government agencies. Even in some colleges and institutions, which admit students without MoE scholarship/ assistantship, the GATE qualification is mandatory. Further, many Public Sector Undertakings (PSUs) have been using the GATE score in their recruitment process.

Exam Details:

Mode of Examination	**Computer Based Test**
Paper Code	CH
Duration of Exam	180 minutes
Total number of Questions	65
Total Marks	100
Language of Examination	English

Exam Pattern:

Sections	**Section I** (General Aptitude)	**Section II** (CH and EM)
Number of Questions	10	55
Marks	5 questions of 1 mark each and 5 questions of 2 marks each	25 questions of 1 mark each and 30 questions of 2 marks each
Negative Marking	For 1-mark MCQ, 1/3 mark will be deducted for a wrong answer. For 2-mark MCQ, 2/3 mark will be deducted for a wrong answer. There will be no negative marking for MSQ & NAT.	
Types of Question	MCQ	MCQ, MSQ, NAT

Duration and Examination Type

All the papers of the GATE 2026 examination will be for 3 hours duration and they consist of 65 questions for a total of 100 marks. Since the examination is an ONLINE computer-based test (CBT), at the end of the stipulated time (3 hours), the computer screen will automatically close the examination inhibiting any further action.

Candidates will be permitted to occupy their allotted seats 40 minutes before the scheduled start of the examination. Candidates can login and start reading the instructions 20 minutes before the start of examination. The late login time (if any) recorded by the computer system MUST NOT be beyond 30 minutes from the actual examination starting time. Candidates will NOT be permitted to login after 30 minutes from the actual examination starting time. Candidates will NOT be permitted to leave the examination hall before the end of the examination.

Pattern of Question Papers

GATE 2026 may contain questions of THREE different types in all the papers:

(i) **Multiple Choice Questions (MCQ)** carrying 1 or 2 marks each, in all the papers and sections. These questions are objective in nature, and each will have a choice of four answers, out of which ONLY ONE choice is correct.

Negative Marking for Wrong Answers: For a wrong answer chosen in a MCQ, there will be negative marking. For 1-mark MCQ, 1/3 mark will be deducted for a wrong answer. Likewise, for 2-mark MCQ, 2/3 marks will be deducted for a wrong answer.

(ii) **Multiple Select Questions (MSQ)** carrying 1 or 2 marks each in all the papers and sections. These questions are objective in nature, and each will have choice of four answers, out of which ONE OR MORE than one choice(s) are/correct.

Note: There is NO negative marking for a wrong answer in MSQ questions. However, there is NO partial credit for choosing partially correct combinations of choices or any single wrong choice.

(iii) **Numerical Answer Type (NAT)** Questions carrying 1 or 2 marks each in most of the papers and sections. For these questions, the answer is a signed real number, which needs to be entered by the candidate using the virtual numeric keypad on the monitor (keyboard of the computer will be disabled). No choices will be shown for these types of questions. The answer can be a number such as 10 or −10 (an integer only). The answer may be in decimals as well, for example, 10.1 (one decimal) or 10.01 (two decimals) or −10.001 (three decimals). These questions will be mentioned with, up to which decimal places, the candidates need to present the answer. Also, for some NAT type problems an appropriate range will be considered while evaluating these questions so that the candidate is not unduly penalized due to the usual round-off

errors. Candidates are advised to do the rounding off at the end of the calculation (not in between steps). Wherever required and possible, it is better to give NAT answer up to a maximum of three decimal places.

Note: There is NO negative marking for a wrong answer in NAT questions. Also, there is NO partial credit in NAT questions.

GATE Year Wise Organising Institute

Organizing Year	Organising Institute
2026	**IIT Guwahati**
2025	**IIT Roorkee**
2024	**IISc Bengaluru**
2023	**IIT Kanpur**
2022	**IIT Kharagpur**
2021	**IIT Bombay**
2020	**IIT Delhi**
2019	**IIT Madras**
2018	**IIT Guwahati**
2017	**IIT Roorkee**
2016	**IISc Bangalore**
2015	**IIT Kanpur**
2014	**IIT Kharagpur**
2013	**IIT Bombay**
2012	**IIT Delhi**
2011	**IIT Madras**
2010	**IIT Guwahati**
2009	**IIT Roorkee**
2008	**IISc Bangalore**
2007	**IIT Kanpur**
2006	**IIT Kharagpur**
2005	**IIT Bombay**
2004	**IIT Delhi**
2003	**IIT Madras**
2002	**IISc Bangalore**
2001	**IIT Kanpur**
2000	**IIT Kharagpur**
1999	**IIT Bombay**
1998	**IIT Delhi**
1997	**IIT Madras**
1996	**IISc Bangalore**

Scholarship/ Assistantship for Postgraduate Programs

To avail the financial assistance (scholarship/ assistantship) for a postgraduate program, the candidate must first secure the admission to a program in one of the centrally funded institutes, by a procedure that could vary from institute to institute. Depending upon the norms adopted by a specific institute or department of the institute, candidates may be admitted directly into a program based on their performance in GATE only; or based on their performance in GATE and an admission test and/or interview conducted by the department to which they have applied and/or the candidate's academic record. In the test/ interview-based selection procedure, as per the MoE guidelines, a minimum of 70% weightage will be given to the performance in GATE and the remaining will be given to the candidate's performance in test/ interview and/or academic record. However, the admitting institutes could prescribe a minimum passing mark in the test/ interview.

Candidates are advised to seek the complete details of the admission procedures and the availability of MoE scholarship/assistantship from the corresponding admitting institutions. The criteria for postgraduate admission with scholarship/ assistantship varies from one institute to the other. The management of the post-graduate scholarship/ assistantship is also the responsibility of the admitting institute. Similarly, reservation of the seats for different categories will be as per the policies and norms of the admitting institution and the Government of India rules.

The admitting institute may also specify the number of candidates who will be provided financial assistance (scholarship), if admission is secured. Qualification in GATE is also a minimum requirement to apply for various fellowships awarded by many Government organizations.

Different types of scholarships and sponsorships opportunities also exist for foreign nationals. Details may be obtained from nearby Indian Mission or from the website of Indian Council for Cultural Relations.

Use of GATE Score for Employment

In the past, several Public Sector Undertakings (PSUs) have used GATE score to shortlist the candidates for employment. A few such organizations are: Airports Authority of India (AAI), Bharat Heavy Electricals Limited (BHEL), Bharat Sanchar Nigam Limited (BSNL), Coal India Limited (CIL), Centre for Railway Information Systems (CRIS), Chenab Valley Power Projects Limited (CVPPL), Damodar Valley Corporation (DVC), Electronics Corporation of India Limited (ECIL), Engineers India Limited (EIL), Gas Authority of India Limited (GAIL), Hindustan Aeronautics Limited (HAL), Indian Oil Corporation Limited (IOCL), Mazagaon Dock Shipbuilders Limited (MDSL), National Aluminium Company Limited (NALCO), National Highways Authority of India (NHAI), NLC India Limited (NLCIL), National Mineral Development Corporation (NMDC), Nuclear Power Corporation of India Limited (NPCIL), National Thermal Power Corporation (NTPC), Oil and Natural Gas Corporation (ONGC), Odisha Power Generation Corporation Limited (OPGC), Power Grid Corporation of India Limited (POWERGRID), Power System Operation Corporation Limited (POSOCO), Rashtriya Ispat Nigam Limited (RINL), Steel Authority of India Limited (SAIL), etc.

Direct recruitment to Group-A level posts in central government, i.e., Senior Field Officer (Tele), Senior Research Officer (Crypto) and Senior Research Officer (S&T) in Cabinet Secretariat, Government of India, is now being carried out on the basis of GATE score. The details of the scheme of recruitment are normally published in National Newspapers/ Employment News/ Rozgar Samachar by the concerned authority.

Some other Government of India Organisations may also utilize GATE 2026 score for their recruitment purpose.

GATE Score

After the evaluation of the answers, the actual (raw) marks obtained by a candidate will be considered for computing the GATE Score. For multi-session test papers, raw marks obtained by the candidates in different sessions will be converted to Normalized marks for that particular subject. Thus, raw marks (for single session test papers) or normalized marks (for multi-session test papers) will be used for computing the GATE Score, based on the qualifying marks.

Calculation of Normalized Marks for Multi-Session Papers

In GATE 2026 examination, some test papers may be conducted in multi-sessions. For such test papers, a suitable normalisation is applied to take into account any variation in the difficulty levels of the question papers across sessions. The normalization is done based on the fundamental assumption that "in all multi-session GATE test papers, the distribution of abilities of candidates is the same across all the sessions". This assumption is justified since the number of candidates appearing in multisession test papers in GATE 2026 will be large and the procedure for allocation of session to candidates is random. Further, it is also ensured that for the same multi-session test paper, the number of candidates allotted in each session is of the same order of magnitude.

Based on the above, and considering various normalization methods, the committee arrived at the following formula for calculating the normalized marks for the multi-session papers.

The normalised marks of the j^{th} candidate in the i^{th} session, denoted by $\widehat{M}_{ij}$ are computed as

$$\widehat{M}_{ij} = \frac{\overline{M}_t^g - M_q^g}{\overline{M}_{ti} - M_{iq}} \left(M_{ij} - M_{iq}\right) + M_q^g$$

where,

M_{ij}, is the actual marks obtained by the j^{th} candidate in the i^{th} session;

$\overline{M}_t^g$ is the average marks of the top 0.1% of the candidates considering all sessions;

M_q^g is the sum of mean and standard deviation marks of the candidates in the paper considering all sessions;

$\overline{M}_{ti}$ is the average marks of the top 0.1% of the candidates in the i^{th} session; and

$\overline{M}_{iq}$ is the sum of the mean marks and standard deviation marks of the i^{th} session.

Calculation of GATE Score for All Test Papers

For all papers for which there is only one session, actual marks obtained by the candidates will be used for calculating the GATE 2026 Score. For papers in multi-sessions, normalized marks will be calculated corresponding to the raw marks obtained by a candidate and the GATE 2026 Score will be calculated based on the normalized marks.

The GATE 2025 score will be computed using the formula given below.

$$\text{GATE Score} = S_q + (S_t - S_q)\frac{M - M_q}{\overline{M_t} - M_q}$$

where
M is the marks obtained by the candidate (actual marks for single session papers and normalized marks for multi-session papers);

M_q is the qualifying marks for the General Category candidate in the paper;

$\overline{M_t}$ is the mean of marks of top 0.1% or top 10 (whichever is larger) of the candidates who appeared in the paper (in case of multi-session papers including all sessions);

$S_q = 350$ is the score assigned to M_q ; and

$S_t = 900$ is the score assigned to $\overline{M_t}$

In GATE 2026, the qualifying marks (M_q) for the general category candidate in each subject will be

Cut-off marks for GENERAL category$= \max(25, \min(40, \mu + \sigma))$

Where μ denotes the mean of marks of all candidates and a denotes the standard deviation of positive marks of all the candidates who appeared for the test paper. The cut-off marks for the other categories may be calculated as per the standard ratio:

Cut-off for OBC-NCL/EWS categories = (9/10) × GENERAL cut-off
Cut-off for SC/ST/PWD categories = (2/3) × GENERAL cut-off

Past Years Cut-off

YEAR	General	OBC-NCL/EWS	SC/ST/PWD
2025	27.70	24.90	18.40
2024	25.00	22.50	16.60
2023	32.10	28.80	21.40
2022	25.30	22.70	16.80
2021	35.10	31.50	23.40
2020	35.70	32.10	23.80
2019	34.80	31.30	23.20
2018	37.80	34.00	25.10
2017	44.33	39.80	29.50
2016	27.52	24.77	18.34

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GENERAL APTITUDE

SECTION 1

SYLLABUS

VERBAL APTITUDE

BASIC ENGLISH GRAMMAR: TENSES, ARTICLES, ADJECTIVES, PREPOSITIONS, CONJUNCTIONS, VERB-NOUN AGREEMENT, & OTHER PARTS OF SPEECH. BASIC VOCABULARY: WORDS, IDIOMS, & PHRASES IN CONTEXT, READING & COMPREHENSION, NARRATIVE SEQUENCING.

QUANTITATIVE APTITUDE

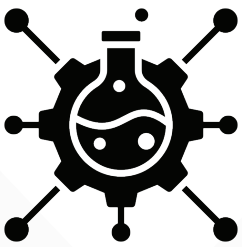
DATA INTERPRETATION: DATA GRAPHS (BAR GRAPHS, PIE CHARTS, & OTHER GRAPHS REPRESENTING DATA), 2- & 3-DIMENSIONAL PLOTS, MAPS & TABLES NUMERICAL COMPUTATION & ESTIMATION: RATIOS, PERCENTAGES, POWERS, EXPONENTS & LOGARITHMS, PERMUTATIONS & COMBINATIONS, & SERIES MENSURATION & GEOMETRY ELEMENTARY STATISTICS & PROBABILITY.

ANALYTICAL APTITUDE

LOGIC: DEDUCTION & INDUCTION, ANALOGY, NUMERICAL RELATIONS & REASONING.

SPATIAL APTITUDE

TRANSFORMATION OF SHAPES: TRANSLATION, ROTATION, SCALING, MIRRORING, ASSEMBLING, & GROUPING PAPER FOLDING, CUTTING, & PATTERNS IN 2 & 3 DIMENSIONS



NUMBER OF QUESTIONS ASKED IN GATE CHEMICAL ENGINEERING (2000 TO 2025)

General Aptitude		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
1.1	Verbal Aptitude	-	-	-	-	-	-	-	-	-	-	4	5	5	3	2	6	4	3	2	3	3	2	1	3	2	3
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GENERAL APTITUDE

CHAPTER 1

Unit 1.1: Verbal Aptitude

[2010: 1 Mark]

1. Which of the following options is the closest in meaning to the word below:
Circuitous
(A) cyclic (B) indirect
(C) confusing (D) crooked

[2010: 1 Mark]

2. Choose the most appropriate word from the options given below to complete the following sentence: If we manage to _____ our natural resources, we would leave a better planet for our children.
(A) uphold (B) restrain
(C) cherish (D) conserve

[2010: 1 Mark]

3. Choose the most appropriate word from the options given below to complete the following sentence: His rather casual remarks on politics _____ his lack of seriousness about the subject
(A) masked (B) belied
(C) betrayed (D) suppressed

[2010: 2 Marks]

4. Modern warfare has changed from large scale clashes of armies to suppression of civilian populations. Chemical agents that do their work silently appear to be suited to such warfare; and regretfully, there exist people in military establishments who think that chemical agents are useful tools for their cause. Which of the following statements best sums up the meaning of the above passage:
(A) Modern warfare has resulted in civil strife.
(B) Chemical agents are useful in modern warfare.
(C) Use of chemical agents in warfare would be undesirable.
(D) People in military establishments like to use chemical agents in war.

[2011: 1 Mark]

5. Choose the word from the options given below that is most nearly opposite in meaning to the given word:
Amalgamate
(A) merge (B) split
(C) collect (D) separate

[2011: 1 Mark]

6. Which of the following options is the closest in the meaning to the word below:
Inexplicable
(A) Incomprehensible (B) Indelible
(C) Inextricable (D) Infallible

[2011: 1 Mark]

7. Choose the most appropriate word(s) from the options given below to complete the following sentence.
I contemplated _____ Singapore for my vacation but decided against it.
(A) to visit (B) having to visit
(C) visiting (D) for a visit

[2011: 1 Mark]

8. Choose the most appropriate word from the options given below to complete the following sentence.
If you are trying to make a strong impression on your audience, you cannot do so by being understated, tentative or_____.
(A) hyperbolic (B) restrained
(C) argumentative (D) indifferent

[2011: 2 Marks]

9. Few school curricula include a unit on how to deal with bereavement and grief, and yet all students at some point in their lives suffer from losses through death and parting.
Based on the above passage which topic would not be included in a unit on bereavement?
(A) how to write a letter of condolence
(B) what emotional stages are passed through in the healing process
(C) what the leading causes of death are
(D) how to give support to a grieving friend

[2012: 1 Mark]

10. Choose the most appropriate alternative from the options given below to complete the following sentence:
Suresh's dog is the one ____ was hurt in the stampede.
(A) that (B) which
(C) who (D) whom

[2012: 1 Mark]

11. Choose the most appropriate alternative from the options given below to complete the following sentence:

Despite several_____ the mission succeeded in its attempt to resolve the conflict.

(A) attempts (B) setbacks
(C) meetings (D) delegations

[2012: 1 Mark]

12. Which one of the following options is the closest in meaning to the word given below?

Mitigate

(A) Diminish (B) Divulge
(C) Dedicate (D) Denote

[2012: 1 Mark]

13. Choose the grammatically INCORRECT sentence:

(A) They gave us the money back less the service charges of Three Hundred rupees.
(B) This country's expenditure is not less than that of Bangladesh.
(C) The committee initially asked for a funding of Fifty Lakh rupees, but later settled for a lesser sum.
(D) This country's expenditure on educational reforms is very less.

[2012: 2 Marks]

14. Wanted Temporary, Part-time persons for the post of Field Interviewer to conduct personal interviews to collect and collate economic data. Requirements: High School-pass, must be available for Day, Evening and Saturday work. Transportation paid, expenses reimbursed.

Which one of the following is the best inference from the above advertisement?

(A) Gender-discriminatory
(B) Xenophobic
(C) Not designed to make the post attractive
(D) Not gender-discriminatory

[2013: 1 Mark]

15. The Headmaster _____ to speak to you.

Which of the following options is incorrect to complete the above sentence?

(A) is wanting (B) wants
(C) want (D) was wanting

[2013: 1 Mark]

16. Mahatma Gandhi was known for his humility as

(A) he played an important role in humiliating exit of British from India.
(B) he worked for humanitarian causes.
(C) he displayed modesty in his interactions.
(D) he was a fine human being.

[2013: 1 Mark]

17. All engineering students (I) should learn mechanics, (II) mathematics and (III) how to do computation (IV).

Which of the above underlined parts of the sentence is not appropriate?

(A) I (B) II
(C) III (D) IV

[2014: 1 Mark]

18. A student is required to demonstrate a high level of comprehension of the subject, especially in the social sciences.

The word closest in meaning to comprehension is

(A) understanding (B) meaning
(C) concentration (D) stability

[2014: 1 Mark]

19. Choose the most appropriate word from the options given below to complete the following sentence.

One of his biggest_____ was his ability to forgive.

(A) vice (B) virtues
(C) choices (D) strength

[2015: 1 Mark]

20. Choose the most appropriate word from the options given below to complete the following sentence.

The principal presented the chief guest with a_____, as token of appreciation.

(A) momento (B) memento
(C) momentum (D) moment

[2015: 1 Mark]

21. Choose the appropriate word/phrase, out of the four options given below, to complete the following sentence:

Frogs_____.

(A) croak (B) roar
(C) hiss (D) patter

[2015: 1 Mark]

22. Choose the word most similar in meaning to the given word:

Educe

(A) Exert (B) Educate
(C) Extract (D) Extend

[2015: 2 Marks]

23. The following question presents a sentence, part of which is underlined. Beneath the sentence you find four ways of phrasing the underlined part. Following the requirements of the standard written English, select the answer that produces the most effective sentence.

Tuberculosis, together with its effects, ranks one of the leading causes of death in India.

(A) ranks as one of the leading causes of death
(B) rank as one of the leading causes of death
(C) has the rank of one of the leading causes of death
(D) are one of the leading causes of death

[2015: 2 Marks]

24. Read the following paragraph and choose the correct statement.

Climate change has reduced human security and threatened human well being. An ignored reality of human progress is that human security largely depends upon environmental security. But on the contrary, human progress seems contradictory to environmental security. To keep up both at the required level is a challenge to be addressed by one and all. One of the ways to curb the climate change may be suitable scientific innovations, while the other may be the Gandhian perspective on small scale progress with focus on sustainability.

(A) Human progress and security are positively associated with environmental security.
(B) Human progress is contradictory to environmental security.
(C) Human security is contradictory to environmental security.
(D) Human progress depends upon environmental security.

[2015: 2 Marks]

25. Humpty Dumpty sits on a wall every day while having lunch. The wall sometimes breaks. A person sitting on the wall falls if the wall breaks.

Which one of the statements below is logically valid and can be inferred from the above sentences?

(A) Humpty Dumpty always falls while having lunch
(B) Humpty Dumpty does not fall sometimes while having lunch
(C) Humpty Dumpty never falls during dinner
(D) When Humpty Dumpty does not sit on the wall, the wall does not break

[2016: 1 Mark]

26. The volume of a sphere of diameter 1 unit is _____than the volume of a cube of side 1 unit.

(A) least (B) less
(C) lesser (D) low

[2016: 1 Mark]

27. The unruly crowd demanded that the accused be_____ without trial.

(A) hanged (B) hanging
(C) hankering (D) hung

[2016: 1 Mark]

28. Choose the statement(s) where the underlined word is used correctly:

(i) A prone is a dried plum.
(ii) He was lying prone on the floor.
(iii) People who eat a lot of fat are prone to heart disease.

(A) (i) and (iii) only (B) (iii) only
(C) (i) and (ii) only (D) (ii) and (iii) only

[2016: 2 Marks]

29. A smart city integrates all modes of transport, uses clean energy and promotes sustainable use of resources. It also uses technology to ensure safety and security of the city, something which critics argue, will lead to a surveillance state. Which of the following can be logically inferred from the above paragraph?

Which of the following can be logically inferred from the above paragraph?

(i) All smart cities encourage the formation of surveillance states.
(ii) Surveillance is an integral part of a smart city.
(iii) Sustainability and surveillance go hand in hand in a smart city.
(iv) There is a perception that smart cities promote surveillance.

(A) (i) and (iv) only (B) (ii) and (iii) only
(C) (iv) only (D) (i) only

[2017: 1 Mark]

30. The bacteria in milk are destroyed when it_____ heated to 80 degree Celsius.

(A) would be (B) will be
(C) is (D) was

[2017: 1 Mark]

31. _____ with someone else's email account is now a very serious offence.

(A) Involving (B) Assisting
(C) Tampering (D) Incubating

[2017: 2 Marks]

32. The old concert hall was demolished because of fears that the foundation would be affected by the construction of the new metro line in the area. Modern technology for underground metro construction tried to mitigate the impact of pressurized air pockets created by the excavation of large amounts of soil. But even with these safeguards, it was feared that the soil below the concert hall would not be stable.

From this, one can infer that

(A) the foundations of old buildings create pressurized air pockets underground, which are difficult to handle during metro construction.
(B) metro construction has to be done carefully considering its impact on the foundations of existing buildings.
(C) old buildings in an area form an impossible hurdle to metro construction in that area.
(D) pressurized air can be used to excavate large amounts of soil from underground areas.

[2018: 1 Mark]

33. "When she fell down the _____, she received many_____ but little help."
The words that best fill the blanks in the above sentence are
(A) stairs, stares (B) stairs, stairs
(C) stares, stairs (D) stares, stares

[2018: 1 Mark]

34. "In spite of being warned repeatedly, he failed to correct his_____ behaviour."
The word that best fills the blank in the above sentence is
(A) rational (B) reasonable
(C) errant (D) good

[2019: 1 Mark]

35. The expenditure on the project_____as follows: equipment Rs. 20 lakhs, salaries Rs. 12 lakhs, and contingency Rs. 3 lakhs.
(A) break down (B) break
(C) breaks down (D) breaks

[2019: 1 Mark]

36. The search engine's business model _____ around the fulcrum of trust.
(A) revolves (B) plays
(C) sinks (D) bursts

[2019: 2 Marks]

37. "A recent High Court judgement has songht to dispel the idea of begging as a disease which leads to its stigmatization and criminalization - and to regard it as a symptom. The underlying disease is the failure of the sate to protect citizens who fall through the social security net."
Which one of the following statements can be inferred from the given passage?
(A) Beggars are lazy people who beg because they are unwilling to work
(B) Beggars are created because of the lack of social welfare schemes
(C) Begging is an offence that has to be dealt with firmly
(D) Begging has to be banned because it adversely affects the welfare of the state

[2020: 1 Mark]

38. Rajiv Gandhi Khel Ratna Award was conferred_____ Mary Kom, a six-time world champion in boxing, recently in a ceremony_____ the Rashtrapati Bhawan (the President's official residence) in New Delhi.
(A) with, at (B) on, in
(C) on, at (D) to, at

[2020: 1 Mark]

39. Despite a string of poor performances, the chances of K. L. Rahul's selection in the team are
(A) slim (B) bright
(C) obvious (D) uncertain

[2020: 1 Mark]

40. Hit by floods, the kharif (summer sown) crops in various parts of the country have been affected. Officials believe that the loss in production of the kharif crops can be recovered in the output of the rabi (winter sown) crops so that the country can achieve its food-grain production target of 291 million tons in the crop year 2019-20 (July-June). They are hopeful that good rains in July-August will help the soil retain moisture for a longer period, helping winter sown crops such as wheat and pulses during the November-February period.
Which of the following statements can be inferred from the given passage?
(A) Officials declared that the food-grain production target will be met due to good rains.
(B) Officials want the food-grain production target to be met by the November-February period.
(C) Officials feel that the food-grain production target cannot be met due to floods.
(D) Officials hope that the food-grain production target will be met due to a good rabi produce.

[2021: 1 Mark]

41. Consider the following sentences:
(i) Everybody in the class is prepared for the exam.
(ii) Babu invited Danish to his home because he enjoys playing chess.
Which of the following is the CORRECT observation about the above two sentences?
(A) (i) is grammatically correct and (ii) is unambiguous
(B) (i) is grammatically incorrect and (ii) is unambiguous
(C) (i) is grammatically correct and (ii) is ambiguous
(D) (i) is grammatically incorrect and (ii) is ambiguous

[2025: 2 Marks]

51. "Why do they pull down and do away with crooked streets, I wonder, which are my delight, and hurt no man living? Every day the wealthier nations are pulling down one or another in their capitals and their great towns: they do not know why they do it; neither do I. It ought to be enough, surely, to drive the great broad ways which commerce needs and which are the life-channels of a modern city, without destroying all history and all the humanity in between: the islands of the past."

(From Hilaire Belloc's "The Crooked Streets")

Based only on the information provided in the above passage, which one of the following statements is true?

(A) The author of the passage takes delight in wondering.

(B) The wealthier nations are pulling down the crooked streets in their capitals.

(C) In the past, crooked streets were only built on islands.

(D) Great broad ways are needed to protect commerce and history.

ANSWER KEY									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
(B)	(D)	(C)	(C)	(A)	(A)	(C)	(B)	(C)	(A)
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
(B)	(A)	(D)	(D)	(C)	(C)	(D)	(A)	(B)	(B)
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
(A)	(C)	(A)	(B)	(B)	(B)	(A)	(D)	(C)	(C)
31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
(C)	(B)	(A)	(C)	(C)	(A)	(B)	(C)	(B)	(D)
41	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**
(C)	(D)	(C)	(B)	(C)	(C)	(B)	(D)	(D)	(D)
51									
(B)									

EXPLANATION

1. Explanation: (B)

Circuitous means round about or not direct. Indirect is closest in meaning to this circuitous.

2. Explanation: (D) The correct statement is:

If we manage to **conserve** our natural resources, we would leave a better planet for our children.

3. Explanation: (C)

Betrayed means to reveal something unintentionally or accidentally that fits well with the given context.

4. Explanation: (C)

The statement that best sums up the meaning of the passage is: (C) Use of chemical agents in warfare would be undesirable.

The passage discusses the shift in modern warfare towards targeting civilian populations and mentions the regrettable fact that some people see chemical agents as useful in this context. The passage implies that the use of chemical agents is problematic and undesirable.

5. Explanation: (A)

The word most nearly opposite in meaning to "Amalgamate" is split. "Amalgamate" means to combine or unite, while "split" means to divide or separate into parts, making them antonyms.

6. Explanation: (A)

"Inexplicable" refers to something that cannot be explained or accounted for, and "incomprehensible" means something that cannot be understood, making them synonymous.

7. Explanation: (C)

"I contemplated **visiting** Singapore for my vacation but decided against it." The verb "contemplated" is usually followed by a gerund (a verb ending in -ing), so "visiting" fits grammatically and conveys the intended meaning.

8. Explanation: (B)

Understated, tentative, and restrained all suggest holding back or being limited in expression. If you're trying to make a strong impression, being restrained would contradict that goal, just like being understated or tentative.

9. Explanation: (C)

'What the leading causes of death are ' is not typically included in a bereavement unit. Bereavement education focuses on coping with loss, understanding emotional stages, and supporting others. Writing condolence letters and providing support are practical skills related to grief. Understanding causes of death is more about medical information and doesn't address the emotional aspects of bereavement.

10. Explanation: (A)

When referring to animals in relative clauses, **"that"** is generally used for specificity. "Who" and "whom" are typically used for people, while "which" is generally

used for objects or when the animal is not being referred to personally. Hence, the sentence should read: "Suresh's dog is the one **that** was hurt in the stampede."

11. Explanation: (B)

"Setbacks" appropriately contrasts with the mission's success, indicating challenges overcome. The other options don't convey this opposing relationship effectively.

12. Explanation: (A)

"Mitigate" means to make something less severe or intense, which is synonymous with "diminish." The other options do not share this meaning.

13. Explanation: (D)

The usage of 'less' is wrong in option 4. 'Less' is generally used as a way of comparing two quantities or amounts. Here, the word 'less' needs to be replaced with the words 'little' or 'low'.

14. Explanation: (D)

The advertisement uses gender-neutral terms like "persons" without specifying any gender. There are no requirements that exclude any gender. Therefore, it is not gender-discriminatory.

15. Explanation: **(C)**

The sentence is: "The Headmaster __ to speak to you."

(A) is wanting: Incorrect. The verb "want" is a stative verb, and stative verbs are generally not used in the continuous tense ("is wanting").

(B) wants: Correct. "Wants" is the appropriate present tense form of the verb that agrees with the singular subject "The Headmaster."

(C) want: Incorrect. The verb "want" is in the base form, which is used for plural subjects or in imperative sentences, but not with a singular subject like "The Headmaster."

(D) was wanting: Incorrect. This is the past continuous tense, and it's not suitable for the context of the sentence, which seems to refer to a current desire.

Thus, the incorrect option is (C) want, as it does not agree with the singular subject "The Headmaster."

16. Explanation: (C)

Gandhi's humility is best reflected in his simple lifestyle, polite speech, and respectful treatment of even opponents. Options (A) and (B) emphasize his achievements and causes, but not humility itself. Option (D) is too general.

The correct answer is: (C) he displayed modesty in his interactions.

17. Explanation: (D)

All engineering students should learn mechanics, mathematics and computation.

18. Explanation: (A)

The word comprehension means the ability to grasp or understand something.

(A) understanding Closest in meaning

(B) meaning → refers to definition, not the act of grasping.

(C) concentration → means focus, not comprehension.

(D) stability → unrelated.

Answer: (A) understanding

19. Explanation: (B)

Sentence: *"One of his biggest _____ was his ability to forgive."*

(A) vice → means a bad habit; doesn't fit.

(B) virtues → good qualities; forgiving is indeed a virtue.

(C) choices → doesn't fit.

(D) strength → possible, but less precise than *virtue* in this moral context.

Answer: (B) virtues

20. Explanation: (B)

- Memento → an object kept as a reminder or token of remembrance.
- Momento → incorrect spelling.
- Momentum → refers to force or speed of movement.
- Moment → refers to a short period of time.

The correct answer is: (B) memento

21. Explanation: (A)

- Frogs croak (the deep, harsh sound they make).
- Roar → lions, tigers.
- Hiss → snakes.
- Patter → sound of raindrops or light footsteps.

So the complete sentence is: "Frogs croak."

22. Explanation: (C)

The correct answer is: (C) Extract

- Educe means to bring out, draw forth, or extract something (like a hidden quality, potential, or meaning).
- Exert → to apply effort.

- Educate → to teach.
- Extend → to make longer or spread out.

So, the synonym of Educe is Extract.

23. Explanation: (A)

The original sentence is: Tuberculosis, together with its effects, ranks one of the leading causes of death in India.

The main subject is Tuberculosis (singular).

The phrase "together with its effects" does not change the singularity of the subject.

So the verb must be singular (→ "ranks", not "rank").

Check the options

(A) ranks as one of the leading causes of death → Correct, grammatically smooth.

(B) rank as one… (plural verb with singular subject).

(C) has the rank of one… (awkward and wordy).

(D) are one… (plural verb with singular subject).

Correct Answer: (A) ranks as one of the leading causes of death

24. Explanation: (B)

"Human security largely depends upon environmental security." → so security depends on environment.

"Human progress seems contradictory to environmental security." → so progress contradicts environment.

Correct Answer: (B) Human progress is contradictory to environmental security

25. Explanation: (B)

Given facts:

1. Humpty Dumpty sits on the wall every day while having lunch.
2. The wall sometimes breaks.
3. A person sitting on the wall falls if the wall breaks.

Interpret

- Humpty always sits on the wall at lunch.
- The wall sometimes breaks, so Humpty will sometimes fall.
- Therefore, Humpty does not always fall (so A).
- He does fall sometimes, but also does not fall sometimes (so B).
- There's no information about dinner (so C).
- The wall can break independently of Humpty (not stated otherwise), so D .

Correct Answer: (B) Humpty Dumpty does not fall sometimes while having lunch.

26. Explanation: (B)

Lesser than is apt because the sentence should be in comparative degree.

Hence option (C) is correct.

27. Explanation: (A)

'hanged' means death by hanging 'hung' is used only with things and not with people.

Therefore option (A) is correct.

28. Explanation: (D)

'Lying prone' means lie down flat. 'Prone to' means vulnerable to.

Hence option (D) is correct.

29. Explanation: (C)

Option (B) is correct.

30. Explanation: (C)

In this sentence, the phrase "The bacteria in milk are destroyed" is in the present tense, and the action of heating is a general statement of fact. Therefore, we use "is" to indicate the present simple tense for actions that are universally true.

The correct answer is (C) is.

31. Explanation: (C)

"Tampering" refers to interfering with or altering something, often in a harmful or unauthorized way. In this case, "tampering with someone else's email account" means unauthorized interference, which is a serious offense.

The correct answer is (C) Tampering.

32. Explanation: (B)

The passage discusses concerns about the impact of metro construction on the foundation of the old concert hall. It highlights the use of modern technology to mitigate the impact of pressurized air pockets created by excavation but emphasizes the fear that the soil beneath the concert hall might not remain stable.

(A) This is not supported by the passage. The concern was about the stability of soil, not the creation of air pockets by foundations of old buildings.

(B) This is supported. The passage suggests that metro construction must be done carefully, considering the impact on the foundations of existing buildings.

(C) This is not correct. The passage doesn't say that old buildings form an "impossible" hurdle, just that there are concerns about foundation stability.

(D) The passage doesn't mention using pressurized air for excavation; rather, it talks about the impact of pressurized air pockets from excavation.
Correct answer: (B) metro construction has to be done carefully considering its impact on the foundations of existing buildings.

33. Explanation: (A)
The sentence is: "When she fell down the _____ , she received many _____ but little help."
First blank: She fell down the → correct word = stairs.
Second blank: She received many looks from people → correct word = stares.
Correct option: (A) stairs, stares

34. Explanation: (C)
The sentence is:
"In spite of being warned repeatedly, he failed to correct his _____ behaviour."
- rational behaviour → means logical behaviour (doesn't fit with "failed to correct").
- reasonable behaviour → means sensible behaviour (again, doesn't fit).
- errant behaviour → means wrong, improper, or bad behaviour (fits perfectly).
- good behaviour → opposite of what's implied.

Correct answer: (C) errant

35. Explanation: (C)
The correct answer is (C) breaks down.
The phrase "breaks down" is used when presenting or explaining the details of a breakdown or distribution of something, like an expenditure or budget. So, the correct sentence is:
"The expenditure on the project breaks down as follows: equipment Rs. 20 lakhs, salaries Rs. 12 lakhs, and contingency Rs. 3 lakhs."

36. Explanation: (A)
The correct answer is (A) revolves.
The phrase "revolves around" is commonly used to indicate that something is centered or based on a particular principle or idea. So, the correct sentence is:
"The search engine's business model revolves around the fulcrum of trust."

37. Explanation: (B)
The correct answer is:
(B) Beggars are created because of the lack of social welfare schemes.
The passage talks about the failure of the state to protect citizens who fall through the social security net, suggesting that begging is a symptom of this failure. This aligns with the idea that the lack of social welfare schemes contributes to the creation of beggars.

38. Explanation: (C)
The award is always conferred *on someone* (not *with* or *to* here).
Ceremonies are held at a place (not *in*).
Correct fill: Rajiv Gandhi Khel Ratna Award was conferred *on Mary Kom … in a ceremony at the Rashtrapati Bhawan.*
Answer: (C) on, at

39. Explanation: (B)
The sentence says *"Despite a string of poor performances …"*
That means his chances are not good.
The correct word is slim.
Answer: (A) slim

40. Explanation: (D)
Floods hit kharif crops, but officials hope rabi crops will make up the loss and help meet the target.
Answer: (D) Officials hope that the food-grain production target will be met due to a good rabi produce.

41. Explanation: (C)
"Everybody in the class is prepared for the exam."
The subject **"Everybody"** is singular, so the verb **"is"** correctly matches the subject.
The sentence is grammatically correct.
"Babu invited Danish to his home because he enjoys playing chess."
The pronoun **"he"** is ambiguous—does it refer to **Babu** or **Danish**?
Since both could reasonably "enjoy playing chess," the sentence is **ambiguous** because it is unclear who the pronoun "he" refers to.

42. Explanation: (D)
(A) This is incorrect because the passage states that AOM sidestep the core problems (poverty and income inequality), not address them.
(B) This is incorrect because the passage does not claim that obesity causes poverty, nor does it suggest a direct relationship between reducing obesity and reducing poverty.

(C) This is incorrect because the passage argues that AOM do not address the core problems, and it does not suggest they are likely to succeed in tackling obesity in a meaningful way.

(D) **This is the correct answer.** The passage suggests that AOM only deal with the surface-level aspects of obesity (like displaying calorie information) and do not tackle the deeper, underlying issues like poverty and income inequality.

43. Explanation: (C)

The correct answer is: (C) tyre / tire

- "Inhaling the smoke from a burning tyre could tire you quickly."
- "Tyre" refers to the rubber covering of a wheel.
- "Tire" means to exhaust or make someone fatigued.

44. Explanation: (B) The correct word is "your", which is the possessive form of "you" indicating ownership of "contributions."

- (A) *you are* → incorrect, it's a subject + verb, not possessive.
- (C) *you're* → contraction of "you are," doesn't fit.
- (D) *yore* → means "long ago," irrelevant here.

Answer: (B) your

45. Explanation: (C)

"References" are something you cite; similarly, "Guidelines" are something you implement. The analogy matches by function.

- (A) *Sight* → related to vision, not relevant.
- (B) *Site* → location/place, not relevant.
- (C) *Cite* → correct, means to refer to (a source).
- (D) *Plagiarise* → opposite of citing, hence incorrect.

Answer: (C) Cite

46. Explanation: (C)

From the passage, the World Bank clearly said:

- It will not offer new financing until Sri Lanka has an adequate macroeconomic policy framework.
- It is only repurposing existing loans to supply essentials (not giving additional funds).
- It mentioned that Sri Lanka needs structural reforms, but did not say it will advise the government.
- It also said the crisis has led to shortages, but did not directly call foreign exchange the root cause.

So, the only statement that can be inferred with certainty is:

(C) According to the World Bank, Sri Lanka does not yet have an adequate macroeconomic policy framework.

47. Explanation: (B)

To solve this analogy, let's analyze the relationship between the words:

Simmer → Seethe → Smolder describes an increasing order of intensity for states of heat or suppressed emotion.

Simmer: A low, barely active state.

Seethe: A more intense, agitated state.

Smolder: An even more intense and destructive state.

Now compare this progression to Break → Raze → [Blank]:

Break: To fracture or split something into pieces, often partially.

Raze: To completely destroy something, especially a structure.

The missing word must signify a more extreme or absolute destruction than **Raze**.

Now, we analyze options:

1. **Obfuscate**: To make something unclear or obscure, unrelated to destruction.
2. **Obliterate**: To completely wipe out, destroy, or erase, fitting the progression from Break → Raze → Obliterate.
3. **Fracture**: To break or crack, similar to "Break" but less intense than "Raze."
4. **Fissure**: A narrow crack or split, less intense than "Break."

48. Explanation: (D)

(i) "the potential for a spectacle"

The subject is "athletics," which is singular. Therefore, the verb should agree with the singular subject. The correct choice is "holds".

(ii) "the crowd"

The subject is "the crowd," which is singular. Therefore, the verb should be "waits", matching the singular subject.

(iii) "Six cross-steps"

This part is describing an action that happens in the singular. So, we need a singular verb form. The correct choice here is "culminate".

(iv) "As his body..."

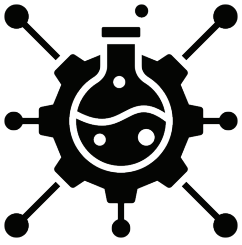
The subject "his body" is singular, and the verb should match. The verb form should be "pivots", which agrees with the singular subject.

HEAT TRANSFER

SECTION 5

SYLLABUS

EQUATION OF ENERGY, STEADY AND UNSTEADY HEAT CONDUCTION, CONVECTION AND RADIATION, THERMAL BOUNDARY LAYER AND HEAT TRANSFER COEFFICIENTS, BOILING, CONDENSATION AND EVAPORATION; TYPES OF HEAT EXCHANGERS AND EVAPORATORS AND THEIR PROCESS CALCULATIONS; DESIGN OF DOUBLE PIPE, SHELL AND TUBE HEAT EXCHANGERS, AND SINGLE AND MULTIPLE EFFECT EVAPORATORS.



NUMBER OF QUESTIONS ASKED IN GATE CHEMICAL ENGINEERING (2000 TO 2025)																											
Heat Transfer		**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
5.1	**Basic Concept**	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	1	-	-	2	-	-
5.2	**Steady and Unsteady Heat Conduction**	-	2	2	3	1	1	2	1	2	1	-	-	-	-	2	-	2	-	1	-	-	-	1	1	2	2
5.3	**Transient Conduction**	2	-	-	1	1	3	-	-	2	1	-	-	3	-	-	1	-	1	1	1	-	-	-	-	1	-
5.4	**Force and Natural Convection**	2	2	-	1	1	2	2	3	1	1	1	-	1	-	-	1	-	1	-	1	-	-	-	1	1	-
5.5	**Radiation Heat Transfer**	1	1	-	-	1	1	1	1	-	1	1	1	1	1	1	1	1	1	-	-	1	1	1	1	1	-
5.6	**Heat Exchangers**	-	1	1	4	3	3	-	1	1	1	3	2	2	2	2	1	1	1	3	2	2	3	3	2	1	3
5.7	**Internal Heat Generation**	-	-	-	-	-	-	2	-	-	-	1	1	1	-	-	-	-	-	-	1	-	1	-	-	-	-
5.8	**Fins, Insulation, and Heat Transfer in Fluids**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	-	-	-
5.9	**Boiling, Condensation and Evaporation**	-	-	-	-	-	2	2	1	-	-	-	1	-	1	-	-	1	1	1	1	1	1	1	-	-	-

CHAPTER 5

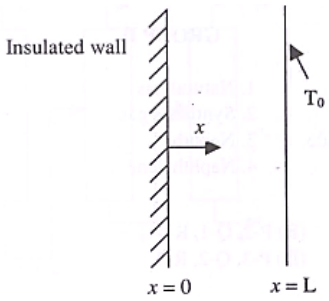
HEAT TRANSFER

Unit 5.1: Basic Concept

Multiple Choice Questions (MCQ)

Common Data for Questions 1 and 2:

A slab of thickness L with one side ($x = 0$) insulated and the other side ($x = L$) maintained at a constant temperature T_0 is shown below.



A uniformly distributed internal heat source produces heat in the slab at the rate of S W/m^3. Assume the heat conduction to be steady and 1-D along the x-direction.

[2009: 2 Marks]

1. The maximum temperature in the slab occurs at x equal to

(A) 0 (B) $L/4$

(C) $L/2$ (D) L

[2009: 2 Marks]

2. The heat flux at $x = L$ is

(A) 0 (B) $SL/4$

(C) $SL/2$ (D) SL

[2020: 1 Mark]

3. Ratio of momentum diffusivity to thermal diffusivity is

(A) Reynolds number (B) Prandtl number

(C) Nusselt number (D) Peclet number

[2023: 1 Mark]

4. Match the quantities in Group 1 with their units in Group 2 listed in the table below

Group 1	Group 2
P) Thermal conductivity	I) $\mathrm{W \cdot m^{-2}\ K^{-1}}$
Q) Convective heat transfer coefficient	II) $\mathrm{W \cdot m^{-1}\ K^{-1}}$
R) Stefan-Boltzmann constant	III) $\mathrm{W.\ K^{-1}}$
S) Heat capacity rate	IV) $\mathrm{W.\ m^{-2}\ K^{-4}}$

(A) P-II, Q-I, R-IV, S-III (B) P-I, Q-II, R-III, S-IV

(C) P-III, Q-IV, R-II, S-I (D) P-IV, Q-I, R-III, S-II

[2023: 2 Marks]

5. Which of the following statements is/are CORRECT?

(A) Bond number includes surface tension.

(B) Jakob number includes latent heat.

(C) Prandtl number includes liquid-vapor density difference.

(D) Biot number includes gravity

ANSWER KEY				
Multiple Choice Questions (MCQ)				
1	**2**	**3**	**4**	**5**
(A)	(D)	(B)	(A)	(A, B)

EXPLANATIONS

Multiple Choice Questions (MCQ)

1. Explanation: (A)

- **Heat Flow and Temperature Gradient**: In a conductive system, heat flows from areas of high temperature to areas of low temperature, and the temperature changes across the material (the gradient, denoted as $\frac{dT}{dx}$ will depend on the thermal conductivity and the heat flux.
- **Insulated Surface**: The left wall of the slab is insulated, which means no heat can enter or leave through that surface. The condition at the insulated surface is $\frac{dT}{dx} = 0$, indicating that the temperature gradient at the boundary is zero. This implies that the temperature at the insulated surface is constant (no change with respect to position), which is a point of **maximum temperature** in the system.
- **Heat Flow Direction**: If the right side of the slab is exposed to a cooler environment or a heat sink (i.e., it's losing heat), the temperature on that side will be lower compared to the left, leading to a **decreasing temperature** from left to right.

2. Explanation: (D)

In steady-state heat conduction with heat generation within the material, the heat flux at a given point, such as x=Lx = Lx=L, can be determined by applying the energy balance and Fourier's law of heat conduction.

Key Assumptions:

Steady-state: The temperature distribution does not change with time.

Heat conduction: The heat flows in the xxx-direction.

Heat generation: There is a volumetric heat generation term, denoted as SSS, with units of $\mathrm{w/m^3}$.

Fourier's Law: The heat flux qx due to conduction is given by Fourier's law:

$$q_x = -k\frac{dT}{dx}$$

Steady-State Energy Balance:

In steady-state, the rate of heat generation is balanced by the rate of heat conduction. This means that the heat generated within the material must be conducted through it.

Heat Generation Rate: The total heat generated per unit volume is S, and over a length L, the total heat generation is S·L (in units of W)

Heat Flux: The heat flux at x=L, due to both conduction and generation, can be given by:

$$\mathrm{qL} = \mathrm{q_{conduction}} + \mathrm{q_{generation}}$$

For heat conduction:

$$q_{conduction} = -k\frac{dT}{dx}|_{x=L}$$

For heat generation:

$$q_{generation} = SL$$

Final Heat Flux at x=L:

The heat flux at x=L will be the sum of the heat conduction and the heat generated:

$$\mathrm{qL} = \mathrm{q_{conduction}} + \mathrm{SL}$$

S·L is the contribution from the heat generation rate.

Thus, the heat flux at x=L is:

$$\mathrm{qL} = \left(-\mathrm{k}\frac{\mathrm{dT}}{\mathrm{dx}}|_{\mathrm{x=L}}\right) + \mathrm{S.L}$$

3. Explanation: (B)

The **Prandtl number (Pr)** is the ratio of **momentum diffusivity** to **thermal diffusivity**. It is a dimensionless number that characterizes the relative thickness of the momentum and thermal boundary layers. It is given by the formula:

$$P_r = \frac{v}{\alpha}$$

Where:

v is the **kinematic viscosity** (momentum diffusivity),

α is the **thermal diffusivity**.

4. Explanation: (A)

Group 1	Group 2
P) Thermal conductivity	I) $\mathrm{W \cdot m^{-1}\,K^{-1}}$ W · $\mathrm{m^{-2}\,K^{-1}}$
Q) Convective heat transfer coefficient	II) $\mathrm{W \cdot m^{-2}\,K^{-1}}$
R) Stefan-Boltzmann constant	III) W. $\mathrm{m^{-2}\,K^{-4}}$W. $\mathrm{K^{-1}}$
S) Heat capacity rate	IV) W. $\mathrm{K^{-1}}$

5. Explanation: (A, B)

(A) **Bond number includes surface tension**: **True**. The **Bond number** is a dimensionless number that characterizes the relative importance of gravitational forces to surface tension forces. It is defined as:

$$B_0 = \frac{\rho G L^2}{\sigma}$$

Therefore, **Bond number** does include surface tension in its definition.

(B) **Jakob number includes latent heat**: **True**. The **Jakob number** is a dimensionless number that compares sensible heat to latent heat. It is defined as:

$$J_a = \frac{h_{fg}\Delta T}{c_p \Delta T}$$

Therefore, **Jakob number** indeed includes latent heat in its definition.

Unit 5.2: Steady and Unsteady Heat Conduction

Multiple Choice Questions (MCQ)

[2001: 2 Marks]

1. A composite flat wall of a furnace is made of two materials A and B. The thermal conductivity of A is twice of that of material B, while the thickness of layer of A is half of that of B. If the temperatures at the two sides of the wall are 400 and 1200 K, then the temperature drop (in K) across the layer of material A is

(A) 125 (B) 133
(C) 150 (D) 160

[2001: 2 Marks]

2. The heat flux (from outside to inside) across an insulating wall with thermal conductivity $k = 0.04\ \mathrm{W/m\ K}$ and thickness 0.16 m is $0\ \mathrm{W/m^2}$. The temperature of the inside wall is $-5^\circ\mathrm{C}$. The outside wall temperature is

(A) $25^\circ\mathrm{C}$ (B) $30^\circ\mathrm{C}$
(C) $35^\circ\mathrm{C}$ (D) $40^\circ\mathrm{C}$

[2002: 2 Marks]

3. A 10 cm diameter steam pipe, carrying steam at $180^\circ\mathrm{C}$, is covered with an insulation (conductivity $= 0.6\ \mathrm{W/m^\circ C}$). It loses heat to the surroundings at $30^\circ\mathrm{C}$. Assume a heat transfer coefficient of $8.0\ \mathrm{W/m^2\ ^\circ C}$ for heat transfer from surface to the surroundings. Neglect wall resistance of the pipe and film resistance of steam. If the insulation thickness is 2 cm , the rate of heat loss from this insulated pipe will be

(A) greater than that of the un-insulated steam pipe
(B) less than that of the un-insulated steam pipe
(C) equal to that of the un-insulated steam pipe
(D) less than the steam pipe with 5 cm insulation

[2002: 2 Marks]

4. A composite wall consists of two plates A and B placed in series normal to the flow of heat. The thermal conductivities are k_A and k_B and the specific heat capacities are C_{pA} and C_{pB}, for plates A and B respectively. Plate B has twice the thickness of plate A. At steady state, the temperature difference across plate A is greater than that across plate B when

(A) $C_{pA} > C_{pB}$ (B) $C_{\rho A} < C_{\rho B}$
(C) $k_A < 0.5k_B$ (D) $k_A > 2k_B$

[2003: 2 Marks]

5. The units of resistance to heat transfer are

(A) $\mathrm{Jm^{-2}\ K^{-1}}$ (B) $\mathrm{Jm^{-1}\ K^{-1}}$
(C) $\mathrm{Wm^{-2}\ K^{-1}}$ (D) $\mathrm{W^{-1}\ m^2\ K}$

[2003: 2 Marks]

6. The inner wall of a furnace is at a temperature of $700^\circ\mathrm{C}$. The composite wall is made of two substances, 10 and 20 cm thick with therma conductivities of 0.05 and $0.1\mathrm{Wm^{-1}{}^\circ C^{-1}}$ respectively. The ambient air is at $30^\circ\mathrm{C}$ and the heat transfer coefficient between the outer suriace of wall and air is $20\ \mathrm{W\ m^{-2}\ ^\circ C^{-1}}$. The rate of hat loss from the outer surface in $\mathrm{W/m^2}$ is

(A) 165.4 (B) 167.5
(C) 172.8 (D) 175

[2003: 2 Marks]

7. For a given ambient air temperature with increase in the thickness of insulation of a hot cylindrical pipe, the rate of heat loss from the surface would

(A) decrease
(B) increase
(C) first decrease and then increase
(D) first increase and then decrease

[2004: 2 Marks]

8. The left face of a one dimensional slab of thickness 0.2 m is maintained at $80^\circ\mathrm{C}$ and the right face is exposed to air at $30^\circ\mathrm{C}$. The thermal conductivity of the slab is $1.2\ \mathrm{W/(mK)}$ and the heat transfer coefficient from the right face is $10\ \mathrm{W/(m^2\ K)}$. At steady state, the temperature of the right face in $^\circ\mathrm{C}$ is

(A) 77.2 (B) 71.2
(C) 63.8 (D) 48.7

[2005: 2 Marks]

9. A circular tube of outer diameter 5 cm and inner diameter 4 cm is used to convey hot fluid. The inner surface of the wall of the tube is at a temperature of $80^\circ\mathrm{C}$, while the outer surface of the wall of the tube is at $25^\circ\mathrm{C}$. What is the rate of heat transport across the tube wall per meter length of the tube at steady state, if the thermal conductivity of the tube wall is $10\ \mathrm{W/(mK)}$?

(A) 13823 W/m (B) 15487 W/m
(C) 17279 W/m (D) 27646 W/m

[2006: 2 Marks]

10. A stagnant liquid film of 0.4 mm thickness is held between two parallel plates. The top plate is maintained at $40^\circ\mathrm{C}$ and the bottom plate is maintained at $30^\circ\mathrm{C}$. If the thermal conductivity of the liquid is $.14\ \mathrm{W/(m\ K)}$, then the steady state heat flux (in W/m²) assuming one dimensional heat transfer is

(A) 3.5 (B) 350
(C) 3500 (D) 7000

[2006: 2 Marks]

11. One dimensional steady state heat transfer occurs from a flat vertical wall of length 0.1 m into the adjacent fluid. The heat flux into this fluid is $1\ \mathrm{W/m^2}$. The wall thermal conductivity is $.73\ \mathrm{W/(mK)}$. If the heat transfer coefficient is $30\ \mathrm{W/(m^2\ K)}$ and the Nusselt number based on the wall length is 20 , then the magnitude of the temperature gradient at the wall on the fluid side (in $\mathrm{K/m}$) is

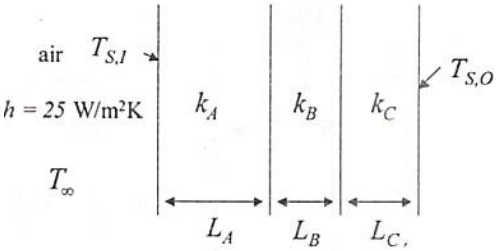
(A) 0.7 (B) 12.14

(C) 120 (D) 140

[2007: 2 Marks]

12. The composite wall of an oven consists of three materials, A, B, and C. Under steady-state operating conditions, the outer surface temperature T_{so} is 20°C, the inner surface temperature is T_{si} 600°C, and the oven air temperature is $T_\infty = 800^\circ$C. For the following data:

- Thermal conductivities: $k_A = 20$ W/(m·K) and $k_C = 50$ W/(m·K),
- Thicknesses: $L_A = 0.3$ m, $L_B = 0.15$ m, and $L_C = 0.15$ m,
- Inner-wall heat transfer coefficient: $h = 25$ W/(m^2 · K), the thermal conductivity k_B (in W/(m·K)) of the material B is calculated as

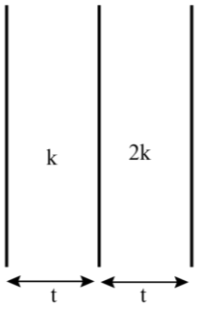


(A) 35 (B) 1.53

(C) 0.66 (D) 0.03

[2008: 2 Marks]

13. Two plates of equal thickness (t) and cross-sectional area, are joined together to form a composite as shown in the figure. If the thermal conductivities of the plates are k and 2 k then, the effective thermal conductivity of the composite is



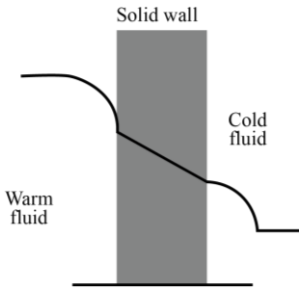
(A) $3\mathrm{k}/2$ (B) $4\mathrm{k}/3$

(C) $3\mathrm{k}/4$ (D) $2k/3$

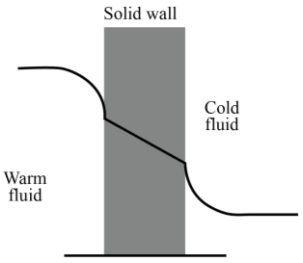
[2008: 2 Marks]

14. The temperature profile for heat transfer from one fluid to another separated by a solid wall is

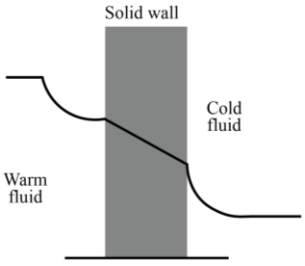
(A)



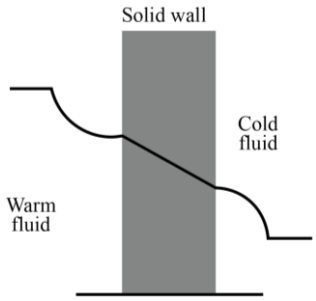
(B)



(C)

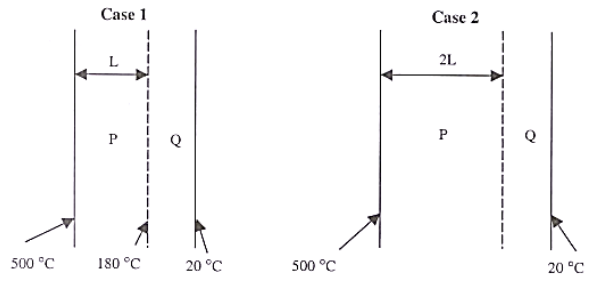


(D)



[2009: 2 Marks]

15. For the composite wall shown below (Case 1), the steady-state interface temperature is 180°C. If the thickness of layer P is doubled (Case 2), then the rate of heat transfer (assuming 1-D conduction) is reduced by

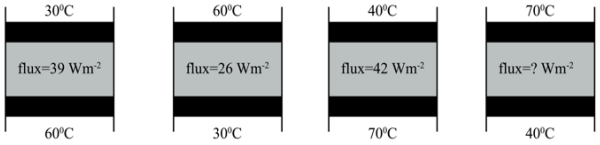


(A) 20% (B) 40%

(C) 50% (D) 70%

[2016: 2 Marks]

16. In an experimental setup, mineral oil is filled in between the narrow gap of two horizontal smooth plates. The setup has arrangements to maintain the plates at desired uniform temperatures. At these temperatures, ONLY the radiative heat flux is negligible. The thermal conductivity of the oil does not vary perceptibly in this temperature range. Consider four experiments at steady state under different experimental conditions, as shown in the figure below. The figure shows plate temperatures and the heat fluxes in the vertical direction.



What is the steady state heat flux (in $\mathrm{W\ m^{-2}}$) with the top plate at $70^{\circ}\mathrm{C}$ and the bottom plate at $40^{\circ}\mathrm{C}$?

(A) 26 (B) 39

(C) 42 (D) 63

[2022: 2 Marks]

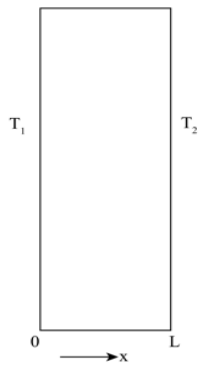
17. Consider a bare long copper wire of 1 mm diameter. Its surface temperature is T_s and the ambient temperature is $T_a (T_s > T_a)$. The wire is to be coated with a 2 mm thick insulation. The convective heat transfer coefficient is $20\ \mathrm{W\ m^{-2}\ K^{-1}}$. Assume that T_s and T_a remain unchanged. To reduce heat loss from the wire, the maximum allowed thermal conductivity of the insulating material, in $\mathrm{W\ m^{-1}K^{-1}}$, rounded off to two decimal places, is

(A) 0.02 (B) 0.04

(C) 0.10 (D) 0.01

[2023: 1 Mark]

18. A slab of thickness L, as shown in the figure below, has cross-sectional area A and constant thermal conductivity k. T_1 and T_2 are the temperatures at $x = 0$ and $x = L$, respectively. Which one of the following options is the CORRECT expression of the thermal resistance for steady-state one-dimensional heat conduction?

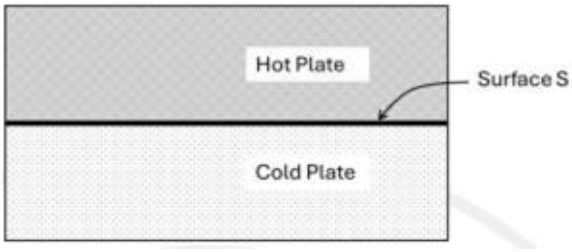


(A) $\frac{L}{kA}$ (B) $\frac{k}{LA}$

(C) $\frac{kA(T_1-T_2)}{L}$ (D) $\frac{A}{Lk}$

[2025: 2 Marks]

19. A hot plate is placed in contact with a cold plate of a different thermal conductivity as shown in the figure. The initial temperature (at time $= 0$) of the hot plate and cold plate are T_h and T_c, respectively. Assume perfect contact between the plates.



Which one of the following is an appropriate boundary condition at the surface S for solving the unsteady state, one-dimensional heat conduction equations for the hot plate and cold plate for > 0?

(A) Temperature at S is same for both the plates

(B) Gradient of temperature at S is same for both the plates

(C) Gradient of temperature vanishes at S

(D) Temperature at S is the average of T_h and T_c

Numerical Answer Type Questions (NAT)

[2014: 2 Marks]

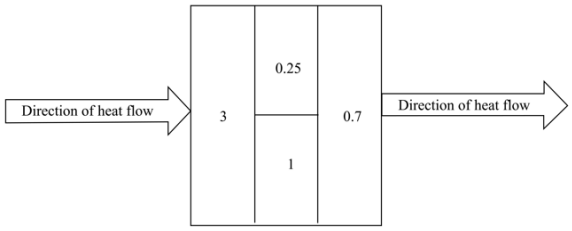
1. A brick wall of 20 cm thickness has thermal conductivity of $0.7\mathrm{W\ m^{-1}\ K^{-1}}$. An insulation of thermal conductivity $0.2\ \mathrm{W\ m^{-1}\ K^{-1}}$ is to be applied on one side of the wall, so that the heat transfer through the wall is reduced by 75%. The same temperature difference is maintained across the wall before and after applying the insulation. The required thickness (in cm) of the insulation is_____.

[2014: 2 Marks]

2. The bottom face of a horizontal slab of thickness 6 mm is maintained at $300\ ^{\circ}\mathrm{C}$. The top face is exposed to a flowing gas at $30\ ^{\circ}\mathrm{C}$. The thermal conductivity of the slab is $1.5\ \mathrm{W\ m^{-1}\ K^{-1}}$ and the convective heat transfer coefficient is $30\ \mathrm{W\ m^{-2}\ K^{-1}}$. At steady state, the temperature (in 'C) of the top face is _____.

[2016: 1 Mark]

3. A composite wall is made of four different materials of construction in the fashion shown below. The resistance (in $\mathrm{K/W}$) of each of the sections of the wall is indicated in the diagram.



The overall resistance (in $\mathbf{K/W}$, rounded off to the first decimal place) of the composite wall, in the direction of heat flow, is _____.

[2018: 2 Marks]

4. **The wall of a pipe of radius 1 m is at a uniform temperature of $200^{\circ}\mathrm{C}$, and is covered by insulation of thickness 0.1 m . The ambient air outside the insulated pipe is at $20^{\circ}\mathrm{C}$ and has heat transfer coefficient of $10\ \mathrm{W\,m^{-2}\,K^{-1}}$. The thermal conductivity of the insulation material is $0.05\ \mathrm{W\,m^{-1}\,K^{-1}}$. If the heat transfer occurs at steady state, the temperature (in $^{\circ}\mathrm{C}$) of the outer surface of insulation is_____ (rounded off to second decimal place).**

[2024: 1 Mark]

5. **The capital cost of a distillation column is Rs.90 lakhs. The cost is to be fully depreciated (salvage value is zero) using the double-declining balance method over 10 years. At the end of two years of continuous operation, the book-value of the column, in lakhs of rupees, rounded off to 1 decimal place, is _____**

[2024: 1 Mark]

6. **The opposite faces of a metal slab of thickness 5 cm and thermal conductivity $400\ \mathrm{W\,m^{-1}\,^{\circ}C^{-1}}$ are maintained at $500^{\circ}\mathrm{C}$ and $200^{\circ}\mathrm{C}$. The area of each face is $.02\ \mathrm{m^2}$. Assume that the heat transfer is steady and occurs only in the direction perpendicular to the faces. The magnitude of the heat transfer rate, in kW, rounded off to the nearest integer, is _____**

[2025: 2 Marks]

7. **An electrical wire of 2 mm diameter and 5 m length is insulated with a plastic layer of thickness 2 mm and thermal conductivity $k = 0.1\ W/(m\ K)$. It is exposed to ambient air at $30^{\circ}C$. For a current of 5 A, the potential drop across the wire is 2 V. The air-side heat transfer coefficient is $20\ W/(m^2\ K)$. Neglecting the thermal resistance of the wire, the steady state temperature at the wire-insulation interface is _____ $^{\circ}C$ (rounded off to 1 decimal place).**

ANSWER KEY									
Multiple Choice Questions (MCQ)									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
(D)	(C)	(A)	(C)	(D)	(A)	(D)	(D)	(B)	(C)
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	
(D)	(B)	(B)	(B)	(B)	(A)	(A)	(A)	(A)	
Numerical Answer Type Questions (NAT)									
1		**2**		**3**		**4**		**5**	
(17.0 to 17.3)		(268 to 274)		(3.88 to 3.92)		(27.8 to 28.6)		(57.5 to 57.5)	
6		**7**							
(48 to 48)		(38.5 to 39.1I							

EXPLANATIONS

Multiple Choice Questions (MCQ)

1. Explanation: (D)

At steady state

$$\frac{1200-400}{\frac{2L}{K_B}+\frac{L}{2K_B}}=\frac{1200-T}{\frac{2L}{K_B}}=\frac{T-400}{\frac{L}{2K_B}}$$

$$1200-T=4T-1600=560K$$

Temperature drop across material A is 560-400=160K

2. Explanation: (C)

$$Q_1=hA\Delta T$$

$$=10\times\pi\times0.2\times L\times(400-300)$$

$$\frac{Q_1}{L}=628.32W/m$$

$$Q_2=\frac{400-300}{\frac{ln\left(\frac{0.15}{0.1}\right)}{2\pi\times0.5}+\frac{1}{10\pi\times0.30\times L}}$$

$$\frac{Q_2}{L}=425.25$$

$$\%\text{ reduction heat loss }=\frac{\frac{Q_1}{L}-\frac{Q_2}{L}}{\frac{Q_1}{L}}\times100$$

$$=\frac{628.32-425.25}{628.32}\times100=32.32\%$$

3. Explanation: (A)

Critical radius of insulation for cylinder is given as

$$r_c=\frac{k_{insulation}}{h_0}$$

$$=\frac{0.6}{8}=7.5\text{cm}$$

Since, radius of pipe (5cm) is less than r_c. so, initially heat flux will increase then decrease. Radius after insulation is (5+2)=7cm.