

## PHYSICAL SCIENCES

PAPER – II  
DEC-21/02

OMR Answer Sheet No. :

Roll No. :

(in figures as in Hall Ticket)

Roll Number in words : .....

021124

Question Booklet Sl. No.

Name &amp; Signature of the Invigilator

.....

.....

No. of Printed Pages : 32

[Maximum Marks : 200]

Time : 2 Hours]

## Instructions for the Candidates

- Write your Roll Number in the space provided on the top of this page.
- This paper consists of **one hundred (100)** multiple choice type of questions. **All** questions are compulsory.
- At the commencement of examination, the question booklet will be given to you. In the first 5 minutes, you are requested to open the booklet and compulsorily examine it as below :
  - To have access to the Question Booklet, tear off the paper seal on the edge of this cover page. Do not accept a booklet without sticker seal and do not accept an open booklet.
  - Tally the number of pages and number of questions in the booklet with the information printed on the cover page. Faulty booklets due to pages/questions missing or duplicate or not in serial order or any other discrepancy should be got replaced immediately by a correct booklet from the invigilator within the period of 5 minutes. Afterwards, neither the Question Booklet will be replaced nor any extra time will be given.
  - After this verification is over, the Test Booklet Number should be entered on the OMR Answer Sheet and the OMR Answer Sheet Number should be entered on this Test Booklet.
- Each item has four alternative responses marked (A), (B), (C) and (D). You have to darken the oval as indicated below on the correct response against each item.  
**Example :** (A) (B) (C) (D) where (B) is the correct response.
- Your responses to the items are to be indicated on the OMR Answer Sheet under Paper – II only. If you mark your response at any place other than in the oval in the OMR Answer Sheet, it will not be evaluated.
- Rough Work is to be done in the end of this booklet.
- If you write your Name, Roll Number, Phone Number or put any mark on any part of the OMR Answer Sheet, except for the space allotted for the relevant entries, which may disclose your identity, or use abusive language or employ any other unfair means, such as change of response by scratching or using white fluid, you will render yourself liable to disqualification.
- You have to return the original OMR Answer Sheet to the invigilator at the end of the examination compulsorily and must not carry it with you outside the Examination Hall. You are however, allowed to carry original question booklet and duplicate copy of OMR Answer Sheet on conclusion of examination.
- Use only Blue/Black Ball point pen.
- Use of any calculator or any electronic devices or log table etc., are prohibited.
- There shall be no negative marking.

## પરીક્ષાર્થીઓ માટે સૂચનાઓ

- આ પાનાની ટોચ પર દર્શાવેલી જગ્યામાં તમારો રોલ નંબર લખો.
- આ પ્રશ્નપત્રમાં બહુવિકલ્પિક ઉત્તરો ધરાવતા સૌ (100) પ્રશ્નો આપેલા છે. બધા જ પ્રશ્નો ફરજિયાત છે.
- પરીક્ષાની શરૂઆતમાં આપને પ્રશ્નપુસ્તિકા આપવામાં આવશે. પ્રથમ પાંચ (૫) મિનિટ દરમિયાન તમારે પ્રશ્નપુસ્તિકા ખોલી અને ફરજિયાતપણે નીચે મુજબ પરીક્ષણ કરવું :
  - પ્રશ્નપુસ્તિકાનો વપરાશ કરવા માટે આ કવર પૃષ્ઠની ધાર પર આપેલ સીલ સ્ટીકર ફાડી નાખો. કોઈપણ સંજોગોમાં સીલ સ્ટીકર વગરની કે ખુલ્લી પ્રશ્નપુસ્તિકા સ્વીકારશો નહીં.
  - કવર પૃષ્ઠ પર છપાયેલ નિર્દેશાનુસાર પ્રશ્નપુસ્તિકાના પ્રશ્નો, પૃષ્ઠો અને સંખ્યાને બરાબર ચકાસી લો. ખામીયુક્ત પ્રશ્નપુસ્તિકા કે જેમાં પ્રશ્નો/પૃષ્ઠો ઓછાં હોય, બે વાર છપાયા હોય, અનુક્રમમાં અથવા અન્ય કોઈ ફરક હોય અર્થાત કોઈપણ સંજોગોમાં ખામીયુક્ત પ્રશ્નપુસ્તિકા સ્વીકારશો નહીં. અને જો ખામીયુક્ત પ્રશ્નપુસ્તિકા મળી હોય તો નિરીક્ષક પાસેથી તુરંત જ બીજી સારી પ્રશ્નપુસ્તિકા મેળવી લેવી. આ માટે ઉમેદવારને પાંચ (૫) મિનિટનો સમયગાળો આપવામાં આવશે. પછીથી, પ્રશ્નપુસ્તિકા બદલવામાં આવશે નહીં કે કોઈ વધારાનો સમયગાળો આપવામાં આવશે નહીં.
  - આ ચકાસણી સમાપ્ત થાય પછી, પ્રશ્નપુસ્તિકાનો નંબર OMR જવાબ પત્રક પર લખવો અને OMR જવાબ પત્રકનો નંબર પ્રશ્નપુસ્તિકા પર લખવો.
- પ્રત્યેક પ્રશ્ન માટે ચાર જવાબ વિકલ્પ (A), (B), (C) અને (D) આપવામાં આવેલ છે. તમારે સાચા જવાબના ઓવલ (oval) ને નીચે આપેલ ઉદાહરણ મુજબ પેનથી ભરીને સંપૂર્ણ કાળું કરવાનું રહેશે.  
**ઉદાહરણ :** (A) (B) (C) (D) કે જ્યાં (B) સાચો જવાબ છે.
- આ પ્રશ્નપુસ્તિકાના પ્રશ્નોના જવાબ અલગથી આપવામાં આવેલ OMR જવાબ પત્રકમાં પેપર-II લખેલ વિભાગમાં જ અંકિત કરવા. જો આપ OMR જવાબ પત્રકમાં આપેલ ઓવલ (oval) સિવાય અન્ય સ્થાને જવાબ અંકિત કરશો તો તે જવાબનું મૂલ્યાંકન કરવામાં આવશે નહીં.
- કાચું કામ (Rough Work) પ્રશ્નપુસ્તિકાના અંતિમ પૃષ્ઠ પર કરવું.
- જો આપ OMR જવાબ પત્રક નિયત જગ્યા સિવાય અન્ય કોઈપણ સ્થાને, આપનું નામ, રોલ નંબર, ફોન નંબર અથવા એવું કોઈ ચિહ્ન કે જેનાથી તમારી ઓળખ થઈ શકે, અંકિત કરશો અથવા અબર ભાષાનો પ્રયોગ કરો, અથવા અન્ય કોઈ અનુચિત સાધનોનો ઉપયોગ કરો, જેમકે અંકિત કરી દીધેલ જવાબ ભૂંસી નાખવો કે સફેદ શાહીનો ઉપયોગ કરી બદલશો તો આપને પરીક્ષા માટે અયોગ્ય જાહેર થઈ શકો છો.
- પરીક્ષા સમય પૂરો થઈ ગયા બાદ ઓરીજનલ OMR જવાબ પત્રક જે તે નિરીક્ષકને ફરજિયાત સોંપી દેવું અને કોઈ પણ સંજોગોમાં તે પરીક્ષા ખંડની બહાર લઈ જવું નહીં. પરીક્ષા પૂર્ણ થયા બાદ ઉમેદવાર ઓરીજનલ પ્રશ્નપુસ્તિકા અને OMR જવાબ પત્રકની ડુપ્લિકેટ કોપી પોતાની સાથે લઈ જઈ શકે છે.
- માત્ર કાળી / ભૂરી બોલ પોઈન્ટ પેન વાપરવી.
- કેલ્ક્યુલેટર, લોગ ટેબલ અને અન્ય ઇલેક્ટ્રોનિક યંત્રોનો ઉપયોગ કરવાની મનાઈ છે.
- ખોટા જવાબ માટે નકારાત્મક ગુણાંકન પ્રથા નથી.



**DO NOT WRITE HERE**



## LOGARITHMS

|    | 0    | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | Mean Differences |   |    |    |    |    |    |    |    |
|----|------|------|------|------|------|------|------|------|------|------|------------------|---|----|----|----|----|----|----|----|
|    |      |      |      |      |      |      |      |      |      |      | 1                | 2 | 3  | 4  | 5  | 6  | 7  | 8  | 9  |
| 10 | 0000 | 0043 | 0086 | 0128 | 0170 | 0212 | 0253 | 0294 | 0334 | 0374 | 4                | 8 | 12 | 17 | 21 | 25 | 29 | 33 | 37 |
| 11 | 0414 | 0453 | 0492 | 0531 | 0569 | 0607 | 0645 | 0682 | 0719 | 0755 | 4                | 8 | 11 | 15 | 19 | 23 | 26 | 30 | 34 |
| 12 | 0792 | 0828 | 0864 | 0899 | 0934 | 0969 | 1004 | 1038 | 1072 | 1106 | 3                | 7 | 10 | 14 | 17 | 21 | 24 | 28 | 31 |
| 13 | 1139 | 1173 | 1206 | 1239 | 1271 | 1303 | 1335 | 1367 | 1399 | 1430 | 3                | 6 | 10 | 13 | 16 | 19 | 23 | 26 | 29 |
| 14 | 1461 | 1492 | 1523 | 1553 | 1584 | 1614 | 1644 | 1673 | 1703 | 1732 | 3                | 6 | 9  | 12 | 15 | 18 | 21 | 24 | 27 |
| 15 | 1761 | 1790 | 1818 | 1847 | 1875 | 1903 | 1931 | 1959 | 1987 | 2014 | 3                | 6 | 8  | 11 | 14 | 17 | 20 | 22 | 25 |
| 16 | 2041 | 2068 | 2096 | 2122 | 2148 | 2175 | 2201 | 2227 | 2253 | 2279 | 3                | 5 | 8  | 11 | 13 | 16 | 18 | 21 | 24 |
| 17 | 2304 | 2330 | 2355 | 2380 | 2405 | 2430 | 2455 | 2480 | 2504 | 2529 | 2                | 5 | 7  | 10 | 12 | 15 | 17 | 20 | 22 |
| 18 | 2553 | 2577 | 2601 | 2625 | 2648 | 2672 | 2696 | 2718 | 2742 | 2765 | 2                | 5 | 7  | 9  | 12 | 14 | 16 | 19 | 21 |
| 19 | 2789 | 2810 | 2833 | 2856 | 2878 | 2900 | 2923 | 2945 | 2967 | 2989 | 2                | 4 | 7  | 9  | 11 | 13 | 15 | 18 | 20 |
| 20 | 3010 | 3032 | 3054 | 3075 | 3096 | 3118 | 3139 | 3160 | 3181 | 3201 | 2                | 4 | 6  | 8  | 11 | 13 | 15 | 17 | 19 |
| 21 | 3222 | 3243 | 3263 | 3284 | 3304 | 3324 | 3345 | 3365 | 3385 | 3404 | 2                | 4 | 6  | 8  | 10 | 12 | 14 | 16 | 18 |
| 22 | 3424 | 3444 | 3464 | 3483 | 3502 | 3522 | 3541 | 3560 | 3579 | 3598 | 2                | 4 | 6  | 8  | 10 | 12 | 14 | 15 | 17 |
| 23 | 3617 | 3636 | 3655 | 3674 | 3692 | 3711 | 3729 | 3747 | 3766 | 3784 | 2                | 4 | 6  | 7  | 9  | 11 | 13 | 15 | 17 |
| 24 | 3802 | 3820 | 3838 | 3856 | 3874 | 3892 | 3909 | 3927 | 3945 | 3962 | 2                | 4 | 5  | 7  | 9  | 11 | 12 | 14 | 16 |
| 25 | 3979 | 3997 | 4014 | 4031 | 4048 | 4065 | 4082 | 4099 | 4116 | 4133 | 2                | 3 | 5  | 7  | 9  | 10 | 12 | 14 | 15 |
| 26 | 4150 | 4166 | 4183 | 4200 | 4216 | 4232 | 4249 | 4265 | 4281 | 4298 | 2                | 3 | 5  | 7  | 8  | 10 | 11 | 13 | 15 |
| 27 | 4314 | 4330 | 4346 | 4362 | 4378 | 4393 | 4409 | 4425 | 4440 | 4456 | 2                | 3 | 5  | 6  | 8  | 9  | 11 | 13 | 14 |
| 28 | 4472 | 4487 | 4502 | 4518 | 4533 | 4548 | 4564 | 4579 | 4594 | 4609 | 2                | 3 | 5  | 6  | 8  | 9  | 11 | 12 | 14 |
| 29 | 4624 | 4639 | 4654 | 4669 | 4683 | 4698 | 4713 | 4728 | 4742 | 4757 | 1                | 3 | 4  | 6  | 7  | 9  | 10 | 12 | 13 |
| 30 | 4771 | 4786 | 4800 | 4814 | 4829 | 4843 | 4857 | 4871 | 4886 | 4900 | 1                | 3 | 4  | 6  | 7  | 9  | 10 | 11 | 13 |
| 31 | 4914 | 4928 | 4942 | 4955 | 4969 | 4983 | 4997 | 5011 | 5024 | 5038 | 1                | 3 | 4  | 6  | 7  | 8  | 10 | 11 | 12 |
| 32 | 5051 | 5065 | 5079 | 5092 | 5106 | 5119 | 5132 | 5146 | 5159 | 5172 | 1                | 3 | 4  | 5  | 7  | 8  | 9  | 11 | 12 |
| 33 | 5185 | 5198 | 5211 | 5224 | 5237 | 5250 | 5263 | 5276 | 5289 | 5302 | 1                | 3 | 4  | 5  | 6  | 8  | 9  | 10 | 12 |
| 34 | 5315 | 5328 | 5340 | 5353 | 5366 | 5378 | 5391 | 5403 | 5416 | 5428 | 1                | 3 | 4  | 5  | 6  | 8  | 9  | 10 | 11 |
| 35 | 5441 | 5453 | 5465 | 5477 | 5490 | 5502 | 5514 | 5527 | 5539 | 5551 | 1                | 2 | 4  | 5  | 6  | 7  | 9  | 10 | 11 |
| 36 | 5563 | 5575 | 5587 | 5599 | 5611 | 5623 | 5635 | 5647 | 5658 | 5670 | 1                | 2 | 4  | 5  | 6  | 7  | 8  | 10 | 11 |
| 37 | 5682 | 5694 | 5706 | 5717 | 5728 | 5740 | 5752 | 5763 | 5775 | 5786 | 1                | 2 | 3  | 5  | 6  | 7  | 8  | 9  | 10 |
| 38 | 5798 | 5809 | 5821 | 5832 | 5843 | 5855 | 5866 | 5877 | 5888 | 5899 | 1                | 2 | 3  | 5  | 6  | 7  | 8  | 9  | 10 |
| 39 | 5911 | 5922 | 5933 | 5944 | 5955 | 5966 | 5977 | 5988 | 5999 | 6010 | 1                | 2 | 3  | 4  | 5  | 7  | 8  | 9  | 10 |
| 40 | 6021 | 6031 | 6042 | 6053 | 6064 | 6075 | 6085 | 6096 | 6107 | 6117 | 1                | 2 | 3  | 4  | 5  | 6  | 8  | 9  | 10 |
| 41 | 6128 | 6138 | 6149 | 6160 | 6170 | 6180 | 6191 | 6201 | 6212 | 6222 | 1                | 2 | 3  | 4  | 5  | 6  | 7  | 8  | 9  |
| 42 | 6232 | 6243 | 6253 | 6263 | 6274 | 6284 | 6294 | 6304 | 6314 | 6325 | 1                | 2 | 3  | 4  | 5  | 6  | 7  | 8  | 9  |
| 43 | 6335 | 6346 | 6356 | 6366 | 6376 | 6386 | 6395 | 6406 | 6416 | 6425 | 1                | 2 | 3  | 4  | 5  | 6  | 7  | 8  | 9  |
| 44 | 6435 | 6444 | 6454 | 6464 | 6474 | 6484 | 6493 | 6503 | 6513 | 6522 | 1                | 2 | 3  | 4  | 5  | 6  | 7  | 8  | 9  |
| 45 | 6532 | 6542 | 6551 | 6561 | 6571 | 6580 | 6590 | 6599 | 6609 | 6618 | 1                | 2 | 3  | 4  | 5  | 6  | 7  | 8  | 9  |
| 46 | 6628 | 6637 | 6646 | 6656 | 6665 | 6675 | 6684 | 6693 | 6702 | 6712 | 1                | 2 | 3  | 4  | 5  | 6  | 7  | 7  | 8  |
| 47 | 6721 | 6730 | 6739 | 6749 | 6758 | 6767 | 6776 | 6785 | 6794 | 6803 | 1                | 2 | 3  | 4  | 5  | 5  | 6  | 7  | 8  |
| 48 | 6812 | 6821 | 6830 | 6839 | 6848 | 6857 | 6866 | 6875 | 6884 | 6893 | 1                | 2 | 3  | 4  | 4  | 5  | 6  | 7  | 8  |
| 49 | 6902 | 6911 | 6920 | 6928 | 6937 | 6946 | 6955 | 6964 | 6972 | 6981 | 1                | 2 | 3  | 4  | 4  | 5  | 6  | 7  | 8  |
| 50 | 6990 | 6998 | 7007 | 7016 | 7024 | 7033 | 7042 | 7050 | 7059 | 7067 | 1                | 2 | 3  | 3  | 4  | 5  | 6  | 7  | 8  |
| 51 | 7076 | 7084 | 7093 | 7101 | 7110 | 7118 | 7126 | 7135 | 7143 | 7152 | 1                | 2 | 3  | 3  | 4  | 5  | 6  | 7  | 8  |
| 52 | 7160 | 7168 | 7177 | 7185 | 7193 | 7202 | 7210 | 7218 | 7226 | 7235 | 1                | 2 | 2  | 3  | 4  | 5  | 6  | 7  | 7  |
| 53 | 7243 | 7251 | 7259 | 7267 | 7275 | 7284 | 7292 | 7300 | 7308 | 7316 | 1                | 2 | 2  | 3  | 4  | 5  | 6  | 6  | 7  |
| 54 | 7324 | 7332 | 7340 | 7348 | 7356 | 7364 | 7372 | 7380 | 7388 | 7396 | 1                | 2 | 2  | 3  | 4  | 5  | 6  | 6  | 7  |

No.  
x = 3.14159  
e = 2.71828

log  
0.49715  
0.43429

$\ln x = \log_e x = (1/M) \log_{10} x$   
 $\log x = \log_{10} x = M \log_e x$

No.  
(1/M) = 2.30259  
M = 0.43429

log  
0.36222  
1.63778



# LOGARITHMS

|    | 0    | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | Mean Differences |   |   |   |   |   |   |   |   |
|----|------|------|------|------|------|------|------|------|------|------|------------------|---|---|---|---|---|---|---|---|
|    |      |      |      |      |      |      |      |      |      |      | 1                | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 55 | 7404 | 7412 | 7419 | 7427 | 7435 | 7443 | 7451 | 7459 | 7466 | 7474 | 1                | 2 | 2 | 3 | 4 | 5 | 5 | 6 | 7 |
| 56 | 7482 | 7490 | 7497 | 7505 | 7513 | 7520 | 7528 | 7536 | 7543 | 7551 | 1                | 2 | 2 | 3 | 4 | 5 | 5 | 6 | 7 |
| 57 | 7559 | 7566 | 7574 | 7582 | 7589 | 7597 | 7604 | 7612 | 7619 | 7627 | 1                | 2 | 2 | 3 | 4 | 5 | 5 | 6 | 7 |
| 58 | 7634 | 7642 | 7649 | 7657 | 7664 | 7672 | 7679 | 7686 | 7694 | 7701 | 1                | 1 | 2 | 3 | 4 | 4 | 5 | 6 | 7 |
| 59 | 7709 | 7716 | 7723 | 7731 | 7738 | 7745 | 7752 | 7760 | 7767 | 7774 | 1                | 1 | 2 | 3 | 4 | 4 | 5 | 6 | 7 |
| 60 | 7782 | 7789 | 7796 | 7803 | 7810 | 7818 | 7825 | 7832 | 7839 | 7846 | 1                | 1 | 2 | 3 | 4 | 4 | 5 | 6 | 6 |
| 61 | 7853 | 7860 | 7868 | 7875 | 7882 | 7889 | 7896 | 7903 | 7910 | 7917 | 1                | 1 | 2 | 3 | 4 | 4 | 5 | 6 | 6 |
| 62 | 7924 | 7931 | 7938 | 7945 | 7952 | 7959 | 7966 | 7973 | 7980 | 7987 | 1                | 1 | 2 | 3 | 3 | 4 | 5 | 6 | 6 |
| 63 | 7993 | 8000 | 8007 | 8014 | 8021 | 8028 | 8035 | 8041 | 8048 | 8055 | 1                | 1 | 2 | 3 | 3 | 4 | 5 | 6 | 6 |
| 64 | 8062 | 8069 | 8075 | 8082 | 8089 | 8096 | 8102 | 8109 | 8116 | 8122 | 1                | 1 | 2 | 3 | 3 | 4 | 5 | 6 | 6 |
| 65 | 8129 | 8136 | 8142 | 8149 | 8156 | 8162 | 8169 | 8176 | 8182 | 8189 | 1                | 1 | 2 | 3 | 3 | 4 | 5 | 6 | 6 |
| 66 | 8195 | 8202 | 8209 | 8215 | 8222 | 8228 | 8235 | 8241 | 8248 | 8254 | 1                | 1 | 2 | 3 | 3 | 4 | 5 | 6 | 6 |
| 67 | 8261 | 8267 | 8274 | 8280 | 8287 | 8293 | 8299 | 8306 | 8312 | 8319 | 1                | 1 | 2 | 3 | 3 | 4 | 5 | 6 | 6 |
| 68 | 8325 | 8331 | 8338 | 8344 | 8351 | 8357 | 8363 | 8370 | 8376 | 8382 | 1                | 1 | 2 | 3 | 3 | 4 | 4 | 5 | 6 |
| 69 | 8388 | 8395 | 8401 | 8407 | 8414 | 8420 | 8426 | 8432 | 8439 | 8445 | 1                | 1 | 2 | 3 | 3 | 4 | 4 | 5 | 6 |
| 70 | 8451 | 8457 | 8463 | 8470 | 8476 | 8482 | 8488 | 8494 | 8500 | 8506 | 1                | 1 | 2 | 2 | 3 | 4 | 4 | 5 | 6 |
| 71 | 8513 | 8519 | 8525 | 8531 | 8537 | 8543 | 8549 | 8555 | 8561 | 8567 | 1                | 1 | 2 | 2 | 3 | 4 | 4 | 5 | 6 |
| 72 | 8573 | 8579 | 8585 | 8591 | 8597 | 8603 | 8609 | 8615 | 8621 | 8627 | 1                | 1 | 2 | 2 | 3 | 4 | 4 | 5 | 6 |
| 73 | 8633 | 8639 | 8645 | 8651 | 8657 | 8663 | 8669 | 8675 | 8681 | 8686 | 1                | 1 | 2 | 2 | 3 | 4 | 4 | 5 | 6 |
| 74 | 8692 | 8698 | 8704 | 8710 | 8716 | 8722 | 8727 | 8733 | 8739 | 8745 | 1                | 1 | 2 | 2 | 3 | 4 | 4 | 5 | 6 |
| 75 | 8751 | 8756 | 8762 | 8768 | 8774 | 8779 | 8785 | 8791 | 8797 | 8802 | 1                | 1 | 2 | 2 | 3 | 3 | 4 | 5 | 6 |
| 76 | 8808 | 8814 | 8820 | 8825 | 8831 | 8837 | 8842 | 8848 | 8854 | 8859 | 1                | 1 | 2 | 2 | 3 | 3 | 4 | 5 | 6 |
| 77 | 8865 | 8871 | 8876 | 8882 | 8887 | 8893 | 8899 | 8904 | 8910 | 8915 | 1                | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| 78 | 8921 | 8927 | 8932 | 8938 | 8943 | 8949 | 8954 | 8960 | 8965 | 8971 | 1                | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| 79 | 8976 | 8982 | 8987 | 8993 | 8998 | 9004 | 9009 | 9015 | 9020 | 9025 | 1                | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| 80 | 9031 | 9036 | 9042 | 9047 | 9053 | 9058 | 9063 | 9069 | 9074 | 9079 | 1                | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| 81 | 9085 | 9090 | 9096 | 9101 | 9106 | 9112 | 9117 | 9122 | 9128 | 9133 | 1                | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| 82 | 9138 | 9143 | 9149 | 9154 | 9159 | 9165 | 9170 | 9175 | 9180 | 9186 | 1                | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| 83 | 9191 | 9196 | 9201 | 9206 | 9212 | 9217 | 9222 | 9227 | 9232 | 9238 | 1                | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| 84 | 9243 | 9248 | 9253 | 9258 | 9263 | 9269 | 9274 | 9279 | 9284 | 9289 | 1                | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| 85 | 9294 | 9299 | 9304 | 9309 | 9315 | 9320 | 9325 | 9330 | 9335 | 9340 | 1                | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| 86 | 9345 | 9350 | 9355 | 9360 | 9365 | 9370 | 9375 | 9380 | 9385 | 9390 | 1                | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| 87 | 9395 | 9400 | 9405 | 9410 | 9415 | 9420 | 9425 | 9430 | 9435 | 9440 | 0                | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| 88 | 9445 | 9450 | 9455 | 9460 | 9465 | 9469 | 9474 | 9479 | 9484 | 9489 | 0                | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| 89 | 9494 | 9499 | 9504 | 9509 | 9513 | 9518 | 9523 | 9528 | 9533 | 9538 | 0                | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| 90 | 9542 | 9547 | 9552 | 9557 | 9562 | 9566 | 9571 | 9576 | 9581 | 9586 | 0                | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| 91 | 9590 | 9595 | 9600 | 9605 | 9609 | 9614 | 9619 | 9624 | 9628 | 9633 | 0                | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| 92 | 9638 | 9643 | 9647 | 9652 | 9657 | 9661 | 9666 | 9671 | 9675 | 9680 | 0                | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| 93 | 9685 | 9689 | 9694 | 9699 | 9703 | 9708 | 9713 | 9717 | 9722 | 9727 | 0                | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| 94 | 9731 | 9736 | 9741 | 9745 | 9750 | 9754 | 9759 | 9763 | 9768 | 9772 | 0                | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| 95 | 9777 | 9782 | 9786 | 9791 | 9795 | 9800 | 9805 | 9809 | 9814 | 9818 | 0                | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| 96 | 9823 | 9827 | 9832 | 9836 | 9841 | 9845 | 9850 | 9854 | 9859 | 9863 | 0                | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| 97 | 9868 | 9872 | 9877 | 9881 | 9886 | 9890 | 9894 | 9899 | 9903 | 9908 | 0                | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| 98 | 9912 | 9917 | 9921 | 9926 | 9930 | 9934 | 9939 | 9943 | 9948 | 9952 | 0                | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |
| 99 | 9956 | 9961 | 9965 | 9969 | 9974 | 9978 | 9983 | 9987 | 9991 | 9996 | 0                | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 |

| P                  | 1      | 2      | 3      | 4      | 5      | 6      | 7      | 8      | 9      | 10     |
|--------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| log e <sup>+</sup> | 0.4343 | 0.8686 | 1.3029 | 1.7372 | 2.1715 | 2.6058 | 3.0401 | 3.4744 | 3.9087 | 4.3429 |
| log e <sup>-</sup> | 1.8657 | 1.1314 | 2.6971 | 2.2628 | 3.8285 | 3.3942 | 4.9599 | 4.5256 | 4.0913 | 3.6571 |

# ANTILOGARITHMS

|     | 0    | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | Mean Differences |   |   |   |   |   |   |   |   |
|-----|------|------|------|------|------|------|------|------|------|------|------------------|---|---|---|---|---|---|---|---|
|     |      |      |      |      |      |      |      |      |      |      | 1                | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| .00 | 1000 | 1002 | 1005 | 1007 | 1009 | 1012 | 1014 | 1016 | 1019 | 1021 | 0                | 0 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| .01 | 1023 | 1026 | 1028 | 1030 | 1033 | 1035 | 1038 | 1040 | 1042 | 1045 | 0                | 0 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| .02 | 1047 | 1050 | 1052 | 1054 | 1057 | 1059 | 1062 | 1064 | 1067 | 1069 | 0                | 0 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| .03 | 1072 | 1074 | 1076 | 1079 | 1081 | 1084 | 1086 | 1089 | 1091 | 1094 | 0                | 0 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| .04 | 1096 | 1099 | 1102 | 1104 | 1107 | 1109 | 1112 | 1114 | 1117 | 1119 | 0                | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| .05 | 1122 | 1125 | 1127 | 1130 | 1132 | 1135 | 1138 | 1140 | 1143 | 1146 | 0                | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| .06 | 1148 | 1151 | 1153 | 1156 | 1159 | 1161 | 1164 | 1167 | 1169 | 1172 | 0                | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| .07 | 1175 | 1178 | 1180 | 1183 | 1186 | 1189 | 1191 | 1194 | 1197 | 1199 | 0                | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 3 |
| .08 | 1202 | 1205 | 1208 | 1211 | 1213 | 1216 | 1219 | 1222 | 1225 | 1227 | 0                | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 3 |
| .09 | 1230 | 1233 | 1236 | 1239 | 1242 | 1245 | 1247 | 1250 | 1253 | 1256 | 0                | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 3 |
| .10 | 1259 | 1262 | 1265 | 1268 | 1271 | 1274 | 1276 | 1279 | 1282 | 1285 | 0                | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 3 |
| .11 | 1288 | 1291 | 1294 | 1297 | 1300 | 1303 | 1306 | 1309 | 1312 | 1315 | 0                | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| .12 | 1318 | 1321 | 1324 | 1327 | 1330 | 1334 | 1337 | 1340 | 1343 | 1346 | 0                | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| .13 | 1349 | 1352 | 1355 | 1358 | 1361 | 1365 | 1368 | 1371 | 1374 | 1377 | 0                | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| .14 | 1380 | 1384 | 1387 | 1390 | 1393 | 1396 | 1400 | 1403 | 1406 | 1409 | 0                | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| .15 | 1413 | 1416 | 1419 | 1422 | 1426 | 1429 | 1432 | 1436 | 1439 | 1442 | 0                | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| .16 | 1445 | 1449 | 1452 | 1455 | 1459 | 1462 | 1466 | 1469 | 1472 | 1476 | 0                | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| .17 | 1479 | 1483 | 1486 | 1489 | 1493 | 1496 | 1500 | 1503 | 1507 | 1510 | 0                | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| .18 | 1514 | 1517 | 1521 | 1524 | 1528 | 1531 | 1535 | 1538 | 1542 | 1545 | 0                | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| .19 | 1549 | 1552 | 1556 | 1560 | 1563 | 1567 | 1570 | 1574 | 1578 | 1581 | 0                | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| .20 | 1585 | 1589 | 1592 | 1596 | 1600 | 1603 | 1607 | 1611 | 1614 | 1618 | 0                | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| .21 | 1622 | 1626 | 1629 | 1633 | 1637 | 1641 | 1644 | 1648 | 1652 | 1656 | 0                | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| .22 | 1660 | 1664 | 1667 | 1671 | 1675 | 1679 | 1683 | 1687 | 1690 | 1694 | 0                | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| .23 | 1698 | 1702 | 1706 | 1710 | 1714 | 1718 | 1722 | 1726 | 1730 | 1734 | 0                | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| .24 | 1738 | 1742 | 1746 | 1750 | 1754 | 1758 | 1762 | 1766 | 1770 | 1774 | 0                | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| .25 | 1778 | 1782 | 1786 | 1791 | 1795 | 1799 | 1803 | 1807 | 1811 | 1816 | 0                | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| .26 | 1820 | 1824 | 1828 | 1832 | 1837 | 1841 | 1845 | 1849 | 1854 | 1858 | 0                | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| .27 | 1862 | 1866 | 1871 | 1875 | 1879 | 1884 | 1888 | 1892 | 1897 | 1901 | 0                | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| .28 | 1906 | 1910 | 1914 | 1919 | 1923 | 1928 | 1932 | 1936 | 1941 | 1946 | 0                | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| .29 | 1950 | 1954 | 1959 | 1963 | 1968 | 1972 | 1977 | 1982 | 1986 | 1991 | 0                | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| .30 | 1996 | 2000 | 2004 | 2009 | 2014 | 2018 | 2023 | 2028 | 2032 | 2037 | 0                | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| .31 | 2042 | 2046 | 2051 | 2056 | 2061 | 2066 | 2070 | 2075 | 2080 | 2084 | 0                | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| .32 | 2089 | 2094 | 2099 | 2104 | 2109 | 2113 | 2118 | 2123 | 2128 | 2133 | 0                | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| .33 | 2138 | 2143 | 2148 | 2153 | 2158 | 2163 | 2168 | 2173 | 2178 | 2183 | 0                | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| .34 | 2188 | 2193 | 2198 | 2203 | 2208 | 2213 | 2218 | 2223 | 2228 | 2234 | 1                | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| .35 | 2239 | 2244 | 2249 | 2254 | 2259 | 2264 | 2270 | 2275 | 2280 | 2286 | 1                | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| .36 | 2291 | 2296 | 2301 | 2307 | 2312 | 2317 | 2323 | 2328 | 2333 | 2339 | 1                | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| .37 | 2344 | 2350 | 2355 | 2360 | 2366 | 2371 | 2377 | 2382 | 2388 | 2393 | 1                | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| .38 | 2399 | 2404 | 2410 | 2415 | 2421 | 2427 | 2432 | 2438 | 2443 | 2449 | 1                | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| .39 | 2455 | 2460 | 2466 | 2472 | 2477 | 2483 | 2489 | 2495 | 2500 | 2506 | 1                | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| .40 | 2512 | 2518 | 2523 | 2529 | 2535 | 2541 | 2547 | 2553 | 2559 | 2564 | 1                | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| .41 | 2570 | 2576 | 2582 | 2588 | 2594 | 2600 | 2606 | 2612 | 2618 | 2624 | 1                | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| .42 | 2630 | 2636 | 2642 | 2649 | 2655 | 2661 | 2667 | 2673 | 2679 | 2686 | 1                | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| .43 | 2692 | 2698 | 2704 | 2710 | 2716 | 2723 | 2729 | 2735 | 2742 | 2748 | 1                | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| .44 | 2754 | 2761 | 2767 | 2773 | 2780 | 2786 | 2793 | 2799 | 2806 | 2812 | 1                | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| .45 | 2818 | 2825 | 2831 | 2838 | 2844 | 2851 | 2858 | 2864 | 2871 | 2877 | 1                | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| .46 | 2884 | 2891 | 2897 | 2904 | 2911 | 2917 | 2924 | 2931 | 2938 | 2944 | 1                | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| .47 | 2951 | 2958 | 2965 | 2972 | 2979 | 2985 | 2992 | 2999 | 3006 | 3013 | 1                | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| .48 | 3020 | 3027 | 3034 | 3041 | 3048 | 3055 | 3062 | 3069 | 3076 | 3083 | 1                | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |
| .49 | 3090 | 3097 | 3105 | 3112 | 3119 | 3126 | 3133 | 3141 | 3148 | 3156 | 1                | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 |



# ANTILOGARITHMS

|     | 0    | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | Mean Differences |   |   |   |    |    |    |    |    |
|-----|------|------|------|------|------|------|------|------|------|------|------------------|---|---|---|----|----|----|----|----|
|     |      |      |      |      |      |      |      |      |      |      | 1                | 2 | 3 | 4 | 5  | 6  | 7  | 8  | 9  |
| .50 | 3162 | 3170 | 3177 | 3184 | 3192 | 3199 | 3206 | 3214 | 3221 | 3228 | 1                | 1 | 2 | 3 | 4  | 4  | 5  | 6  | 7  |
| .51 | 3236 | 3243 | 3251 | 3258 | 3266 | 3273 | 3281 | 3289 | 3296 | 3304 | 1                | 2 | 2 | 3 | 4  | 5  | 5  | 6  | 7  |
| .52 | 3311 | 3319 | 3327 | 3334 | 3342 | 3350 | 3357 | 3365 | 3373 | 3381 | 1                | 2 | 2 | 3 | 4  | 5  | 5  | 6  | 7  |
| .53 | 3388 | 3396 | 3404 | 3412 | 3420 | 3428 | 3436 | 3443 | 3451 | 3459 | 1                | 2 | 2 | 3 | 4  | 5  | 6  | 6  | 7  |
| .54 | 3467 | 3475 | 3483 | 3491 | 3499 | 3508 | 3516 | 3524 | 3532 | 3540 | 1                | 2 | 2 | 3 | 4  | 5  | 6  | 6  | 7  |
| .55 | 3548 | 3556 | 3564 | 3573 | 3581 | 3589 | 3597 | 3606 | 3614 | 3622 | 1                | 2 | 2 | 3 | 4  | 5  | 6  | 7  | 7  |
| .56 | 3631 | 3639 | 3648 | 3656 | 3664 | 3673 | 3681 | 3690 | 3698 | 3707 | 1                | 2 | 3 | 3 | 4  | 5  | 6  | 7  | 8  |
| .57 | 3715 | 3724 | 3733 | 3741 | 3750 | 3758 | 3767 | 3776 | 3784 | 3793 | 1                | 2 | 3 | 3 | 4  | 5  | 6  | 7  | 8  |
| .58 | 3802 | 3811 | 3819 | 3828 | 3837 | 3846 | 3855 | 3864 | 3873 | 3882 | 1                | 2 | 3 | 4 | 4  | 5  | 6  | 7  | 8  |
| .59 | 3890 | 3899 | 3908 | 3917 | 3926 | 3935 | 3944 | 3954 | 3963 | 3972 | 1                | 2 | 3 | 4 | 5  | 5  | 6  | 7  | 8  |
| .60 | 3981 | 3990 | 3999 | 4008 | 4018 | 4027 | 4036 | 4046 | 4055 | 4064 | 1                | 2 | 3 | 4 | 5  | 6  | 6  | 7  | 8  |
| .61 | 4074 | 4083 | 4093 | 4102 | 4111 | 4121 | 4130 | 4140 | 4150 | 4159 | 1                | 2 | 3 | 4 | 5  | 6  | 7  | 8  | 9  |
| .62 | 4169 | 4178 | 4188 | 4198 | 4207 | 4217 | 4227 | 4236 | 4246 | 4256 | 1                | 2 | 3 | 4 | 5  | 6  | 7  | 8  | 9  |
| .63 | 4266 | 4276 | 4285 | 4295 | 4305 | 4315 | 4325 | 4335 | 4345 | 4355 | 1                | 2 | 3 | 4 | 5  | 6  | 7  | 8  | 9  |
| .64 | 4365 | 4375 | 4385 | 4395 | 4405 | 4415 | 4425 | 4435 | 4445 | 4457 | 1                | 2 | 3 | 4 | 5  | 6  | 7  | 8  | 9  |
| .65 | 4467 | 4477 | 4487 | 4498 | 4508 | 4519 | 4529 | 4539 | 4550 | 4560 | 1                | 2 | 3 | 4 | 5  | 6  | 7  | 8  | 9  |
| .66 | 4571 | 4581 | 4592 | 4603 | 4613 | 4624 | 4634 | 4645 | 4656 | 4667 | 1                | 2 | 3 | 4 | 5  | 6  | 7  | 9  | 10 |
| .67 | 4677 | 4688 | 4699 | 4710 | 4721 | 4732 | 4742 | 4753 | 4764 | 4775 | 1                | 2 | 3 | 4 | 5  | 7  | 8  | 9  | 10 |
| .68 | 4786 | 4797 | 4808 | 4819 | 4831 | 4842 | 4853 | 4864 | 4875 | 4887 | 1                | 2 | 3 | 4 | 6  | 7  | 8  | 9  | 10 |
| .69 | 4898 | 4909 | 4920 | 4932 | 4943 | 4955 | 4966 | 4977 | 4989 | 5000 | 1                | 2 | 3 | 5 | 6  | 7  | 8  | 9  | 10 |
| .70 | 5012 | 5023 | 5035 | 5047 | 5058 | 5070 | 5082 | 5093 | 5105 | 5117 | 1                | 2 | 4 | 5 | 6  | 7  | 8  | 9  | 11 |
| .71 | 5129 | 5140 | 5152 | 5164 | 5176 | 5188 | 5200 | 5212 | 5224 | 5236 | 1                | 2 | 4 | 5 | 6  | 7  | 8  | 10 | 11 |
| .72 | 5248 | 5260 | 5272 | 5284 | 5297 | 5309 | 5321 | 5333 | 5346 | 5358 | 1                | 2 | 4 | 5 | 6  | 7  | 9  | 10 | 11 |
| .73 | 5370 | 5383 | 5396 | 5408 | 5420 | 5433 | 5446 | 5458 | 5470 | 5483 | 1                | 3 | 4 | 5 | 6  | 8  | 9  | 10 | 11 |
| .74 | 5495 | 5508 | 5521 | 5534 | 5546 | 5559 | 5572 | 5585 | 5598 | 5610 | 1                | 3 | 4 | 5 | 6  | 8  | 9  | 10 | 12 |
| .75 | 5623 | 5636 | 5649 | 5662 | 5675 | 5689 | 5702 | 5715 | 5728 | 5741 | 1                | 3 | 4 | 5 | 7  | 8  | 9  | 10 | 12 |
| .76 | 5754 | 5768 | 5781 | 5794 | 5808 | 5821 | 5834 | 5848 | 5861 | 5875 | 1                | 3 | 4 | 5 | 7  | 8  | 9  | 11 | 12 |
| .77 | 5888 | 5902 | 5916 | 5929 | 5943 | 5957 | 5970 | 5984 | 5998 | 6012 | 1                | 3 | 4 | 5 | 7  | 8  | 10 | 11 | 12 |
| .78 | 6026 | 6039 | 6053 | 6067 | 6081 | 6095 | 6109 | 6124 | 6138 | 6152 | 1                | 3 | 4 | 5 | 7  | 8  | 10 | 11 | 13 |
| .79 | 6166 | 6180 | 6194 | 6208 | 6223 | 6237 | 6252 | 6266 | 6281 | 6295 | 1                | 3 | 4 | 5 | 7  | 9  | 10 | 11 | 13 |
| .80 | 6310 | 6324 | 6339 | 6353 | 6368 | 6383 | 6397 | 6412 | 6427 | 6442 | 1                | 3 | 4 | 5 | 7  | 9  | 10 | 12 | 13 |
| .81 | 6457 | 6471 | 6486 | 6501 | 6516 | 6531 | 6546 | 6561 | 6577 | 6592 | 2                | 3 | 5 | 6 | 8  | 9  | 11 | 12 | 14 |
| .82 | 6607 | 6622 | 6637 | 6653 | 6668 | 6683 | 6699 | 6714 | 6730 | 6745 | 2                | 3 | 5 | 6 | 8  | 9  | 11 | 12 | 14 |
| .83 | 6761 | 6776 | 6792 | 6808 | 6823 | 6839 | 6855 | 6871 | 6887 | 6903 | 2                | 3 | 5 | 6 | 8  | 9  | 11 | 13 | 14 |
| .84 | 6918 | 6934 | 6950 | 6966 | 6982 | 6998 | 7015 | 7031 | 7047 | 7063 | 2                | 3 | 5 | 6 | 8  | 10 | 11 | 13 | 15 |
| .85 | 7079 | 7096 | 7112 | 7129 | 7145 | 7161 | 7178 | 7194 | 7211 | 7228 | 2                | 3 | 5 | 7 | 8  | 10 | 12 | 13 | 15 |
| .86 | 7244 | 7261 | 7278 | 7295 | 7311 | 7328 | 7345 | 7362 | 7379 | 7396 | 2                | 3 | 5 | 7 | 8  | 10 | 12 | 13 | 15 |
| .87 | 7413 | 7430 | 7447 | 7464 | 7482 | 7499 | 7516 | 7534 | 7551 | 7568 | 2                | 3 | 5 | 7 | 9  | 10 | 12 | 14 | 16 |
| .88 | 7586 | 7603 | 7621 | 7638 | 7655 | 7674 | 7691 | 7709 | 7727 | 7745 | 2                | 4 | 6 | 7 | 9  | 11 | 12 | 14 | 16 |
| .89 | 7762 | 7780 | 7798 | 7816 | 7834 | 7852 | 7870 | 7889 | 7907 | 7925 | 2                | 4 | 6 | 7 | 9  | 11 | 13 | 14 | 16 |
| .90 | 7943 | 7962 | 7980 | 7998 | 8017 | 8035 | 8054 | 8072 | 8091 | 8110 | 2                | 4 | 6 | 7 | 9  | 11 | 13 | 15 | 17 |
| .91 | 8128 | 8147 | 8166 | 8185 | 8204 | 8222 | 8241 | 8260 | 8279 | 8298 | 2                | 4 | 6 | 8 | 9  | 11 | 13 | 15 | 17 |
| .92 | 8316 | 8337 | 8356 | 8375 | 8395 | 8414 | 8433 | 8453 | 8472 | 8492 | 2                | 4 | 6 | 8 | 10 | 12 | 14 | 15 | 17 |
| .93 | 8511 | 8531 | 8551 | 8570 | 8590 | 8610 | 8630 | 8650 | 8670 | 8690 | 2                | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| .94 | 8710 | 8730 | 8750 | 8770 | 8790 | 8810 | 8831 | 8851 | 8872 | 8892 | 2                | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 |
| .95 | 8913 | 8933 | 8954 | 8974 | 8995 | 9016 | 9036 | 9057 | 9078 | 9099 | 2                | 4 | 6 | 8 | 10 | 12 | 15 | 17 | 19 |
| .96 | 9120 | 9141 | 9162 | 9183 | 9204 | 9226 | 9247 | 9268 | 9290 | 9311 | 2                | 4 | 6 | 8 | 11 | 13 | 15 | 17 | 19 |
| .97 | 9333 | 9354 | 9376 | 9397 | 9418 | 9441 | 9463 | 9484 | 9506 | 9528 | 2                | 4 | 7 | 9 | 11 | 13 | 15 | 17 | 20 |
| .98 | 9550 | 9572 | 9594 | 9616 | 9638 | 9661 | 9683 | 9705 | 9727 | 9750 | 2                | 4 | 7 | 9 | 11 | 13 | 15 | 18 | 20 |
| .99 | 9772 | 9795 | 9817 | 9840 | 9863 | 9886 | 9908 | 9931 | 9954 | 9977 | 2                | 5 | 7 | 9 | 11 | 14 | 16 | 18 | 20 |





**PHYSICAL SCIENCES**  
**Paper – II**

- What is the directional derivative of the function  $\phi = x^2 - y^2 + 2z^2$  at the point  $P(1, 2, 3)$  in the direction of the line PQ, where Q is the point  $(5, 0, 4)$  ?  
 (A)  $-28/\sqrt{21}$  (B)  $28/\sqrt{21}$   
 (C)  $\sqrt{21}/28$  (D)  $-\sqrt{21}/28$
- If  $\vec{F}$  is a conservative force field, then the value of  $\text{curl } \vec{F}$  is  
 (A) 0 (B) 1 (C)  $\vec{\nabla} \cdot \vec{F}$  (D) -1
- A matrix is given by  $M = \frac{1}{\sqrt{2}} \begin{pmatrix} i & 1 \\ 1 & i \end{pmatrix}$ . The eigenvalues of the matrix M are  
 (A) Real and positive (B) Purely imaginary with modulus 1  
 (C) Complex with modulus 1 (D) Real and negative
- If  $g_{\mu\nu}$  is covariant fundamental tensor of rank 2 and  $g^{\nu\sigma}$  is the contravariant fundamental tensor of rank 2, then their product  $g_{\mu\nu} g^{\nu\sigma}$  is  
 (A) contravariant tensor of rank 4  
 (B) covariant tensor of rank 4  
 (C) zero  
 (D)  $\delta_\mu^\sigma$
- Consider the Bessel's equation ( $\nu = 0$ ),  $\frac{d^2y}{dz^2} + \frac{1}{z} \frac{dy}{dz} + y = 0$ .  
 Which one of the following statements is correct ?  
 (A) Equation has regular singular points at  $z = 0$  and  $z = \infty$ .  
 (B) Equation has two linearly independent solutions that are entire.  
 (C) Equation has an entire solution and a second linearly independent solution singular at  $z = 0$ .  
 (D) Limit  $z \rightarrow \infty$  taken along x-axis exists for both the linearly independent solutions.



6. The generating function  $F(x, t) = \sum_{n=0}^{\infty} P_n(x)t^n$  for the Legendre Polynomials  $P_n(x)$  is  $F(x, t) = (1 - 2xt + t^2)^{-1/2}$ . The value of  $P_3(-1)$  is

- (A)  $5/2$  (B)  $3/2$   
(C)  $+1$  (D)  $-1$

7. The residue of  $\frac{z}{(z-a)(z-b)}$  at infinity is

- (A)  $-1$  (B)  $+1$   
(C)  $-i$  (D)  $+i$

8. For the Fourier series of the following function of period  $2\pi$

$$f(x) = \begin{cases} 0 & -\pi < x < 0 \\ 1 & 0 < x < \pi \end{cases}$$

The ratio (to the nearest integer) of the Fourier coefficients of the first and the third harmonic is

- (A) 1 (B) 2  
(C) 3 (D) 6

9. The Fourier transform  $F[\delta(x-a)] = \exp(-2\pi i a u)$  will correspond to

- (A)  $\delta(x-a) - \delta(x+a)$  (B) a constant  
(C)  $\frac{1}{2} [\delta(x-a) + i \delta(x+a)]$  (D)  $\frac{1}{2} [\delta(x-a) + \delta(x+a)]$

10. The inverse transformation of  $e^{-\sqrt{s}}$  is

- (A)  $\frac{1}{2\sqrt{\pi}} \frac{e^{-1/4t}}{t^{3/2}}$  (B)  $\frac{1}{\sqrt{\pi}} \frac{t^{3/2}}{e^{-1/4t}}$   
(C)  $-1/4t / t^{3/2}$  (D)  $t^{3/2} / e^{-1/4t}$





11. Bessel's function  $J_{\frac{1}{2}}$  is given by

(A)  $\sqrt{\frac{2\pi}{x}} \sin x$

(B)  $\sqrt{\frac{2\pi}{x}} \cos x$

(C)  $\sqrt{\frac{x}{2\pi}} \cos x$

(D)  $\sqrt{\frac{2}{\pi x}} \sin x$

12. The local truncation error in Heun's method is of the order of

(A)  $h^2$

(B)  $h^3$

(C)  $h^4$

(D)  $h^5$

13. **Assertion (A)** : Newton's first law of motion is a special case of the Newton's second law of motion.

**Reason (R)** : The state of rest can be considered as a special case of state of uniform motion when  $\vec{V} = 0$ .

(A) Assertion (A) is true, but Reason (R) is false

(B) Assertion (A) is false, but Reason (R) is true

(C) Both Assertion (A) and Reason (R) are true; and Reason (R) is correct explanation of Assertion (A)

(D) Both Assertion (A) and Reason (R) are true; but Reason (R) is not correct explanation of Assertion (A)

14. Newton's first law of motion introduces the concept of

i. State of rest

ii. Force

iii. Inertia.

Choose correct option from the following.

(A) Only (i) is true

(B) Only (ii) is true

(C) Only (ii) and (iii) are true

(D) (i), (ii) and (iii) are true



15. Choose the appropriate example for the forces.

a.  $\vec{F} = m\vec{a}$   
 $a = \text{constant}$

b.  $\vec{F} = \vec{F}(\vec{r})$

c.  $\vec{F} = \vec{F}(t)$

d.  $\vec{F} = \vec{F}(\vec{r})$

i. The frictional force experienced by a particle moving in a viscous medium

ii. The force experienced by a particle due to earth's gravity, near the surface of earth

iii. The force experienced by a charged particle in an alternating field

iv. The force experienced by a particle performing linear simple harmonic motion

|     | a   | b   | c   | d   |
|-----|-----|-----|-----|-----|
| (A) | ii  | iv  | iii | i   |
| (B) | i   | iii | iv  | ii  |
| (C) | iii | iv  | i   | ii  |
| (D) | iv  | i   | ii  | iii |

16. If a particle of mass  $m$  moving under a conservative force oscillates between  $x_1$  and  $x_2$ , the period of oscillation is  
 (Here  $v(x)$  is the potential energy.)

(A)  $T = \int_{x_1}^{x_2} \left[ \frac{2}{v(x_2) - v(x_1)} \right] dx$

(B)  $T = \int_{x_1}^{x_2} \left[ \frac{v(x_2) - v(x_1)}{2} \right] dx$

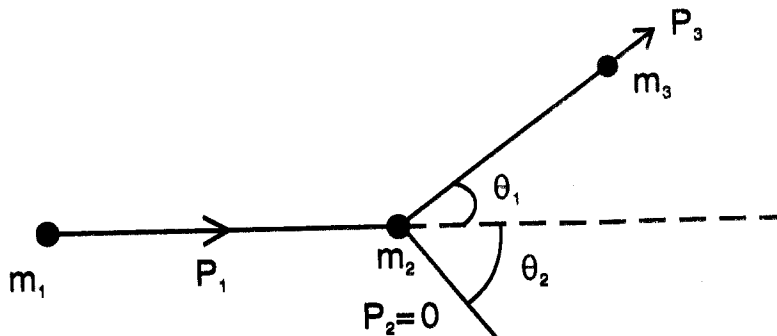
(C)  $T = \int_{x_1}^{x_2} \left[ \frac{v(x_2) - v(x_1)}{2m} \right]^{1/2} dx$

(D)  $T = \int_{x_1}^{x_2} \left[ \frac{m}{2\{v(x_2) - v(x_1)\}} \right]^{1/2} dx$



17. In the case of inelastic collisions, a particle of mass  $m_1$  collides with a particle of mass  $m_2$  initially at rest. After collision, these particles fly apart as different particles of masses  $m_3$  and  $m_4$ , respectively (see figure).

The amount of kinetic energy absorbed or released in this process is



(A)  $Q = \frac{P_1^2}{2m_1} - \frac{P_3^2}{2m_3} - \frac{P_4^2}{2m_4}$

(B)  $Q = \frac{P_1^2}{2m_1} + \frac{P_3^2}{2m_3} + \frac{P_4^2}{2m_4}$

(C)  $Q = \left( \frac{P_1}{2m_1} \right)^2 - \left( \frac{P_3}{2m_3} + \frac{P_4}{2m_4} \right)^2$

(D)  $Q = \left( \frac{P_1}{2m_1} \right)^2 + \left( \frac{P_3}{2m_3} + \frac{P_4}{2m_4} \right)^2$

18. When  $\frac{v}{c} < \frac{1}{10}$ , the classical expressions for kinetic energy and linear momentum may be used with an error of

(A) 10%

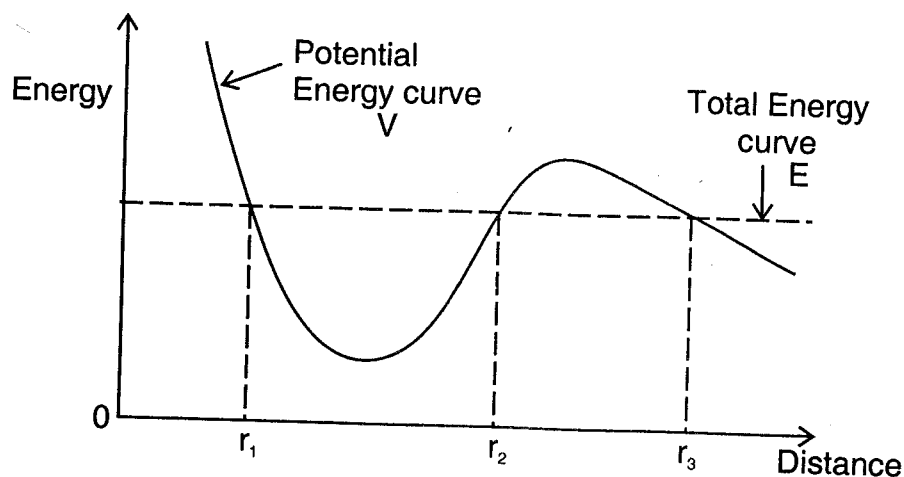
(B) zero

(C) 0.1%

(D) less than 1%



19. The energy curve for the motion of a particle in an arbitrary potential field is shown in the following figure. Choose the correct statement.



- (A) The motion of the particle is bounded for the region  $r < r_1$ .
- (B) The motion of the particle is bounded for the region  $r_1 \leq r \leq r_2$ .
- (C) The motion of the particle is bounded for the region  $r_2 < r < r_3$ .
- (D) The motion of the particle is bounded for the region  $r \geq r_3$ .
20. Consider a system of light strings stretched with force  $F$  having  $n$  equal masses  $m$  placed along it with equal spacing of interval  $l$ . For small transverse oscillations of the particles,
- The slowest mode is the one in which all particles are oscillating in the same direction.
  - The fastest mode has the adjacent particles oscillating in opposite directions.
- (A) Only (i) is true
- (B) Only (ii) is true
- (C) Both (i) and (ii) are true
- (D) None of the above
21. The Jacobi identity is
- (A)  $[u, [v, w]] + [v, [w, u]] + [w, [u, v]] = 0$
- (B)  $[u, [v, w]] + [v, [w, u]] + [w, [u, v]] \neq 0$
- (C)  $[u, [w, v]] + [v, [w, u]] + [w, [u, v]] = 0$
- (D)  $[u, [w, v]] + [v, [w, u]] + [w, [v, u]] = 0$





22. The Hamiltonian's canonical equations of motion in terms of Poisson Brackets are

- (A)  $\dot{q} = [H, p], \dot{p} = [H, q]$
- (B)  $\dot{q} = [p, H], \dot{p} = [q, H]$
- (C)  $\dot{q} = [H, q], \dot{p} = [H, p]$
- (D)  $\dot{q} = [q, H], \dot{p} = [p, H]$

23. The state of the system in classical mechanics can be obtained if

- (A) Position  $x(t)$  at time  $t$  is known
- (B) Velocity  $v(t)$  at time  $t$  is known
- (C) Both position  $x(t)$  and velocity  $v(t)$  at time  $t$  are known
- (D) Any of position  $x(t)$  and velocity  $v(t)$  at time  $t$  is known

24. If the wavelength of an electromagnetic wave is 1 nm, then the frequency of the electromagnetic wave is

- (A)  $3 \times 10^{17}$  Hz
- (B)  $3 \times 10^{16}$  Hz
- (C)  $1.5 \times 10^{16}$  Hz
- (D)  $1.5 \times 10^{17}$  Hz

25. How much is the inductance of a coil that induces 10 volt when its current changes at a rate of 4 Ampere per second ?

- (A) 0.1 H
- (B) 40 H
- (C) 4 mH
- (D) 2.5 H

26. Which of the following is not electromagnetic wave ?

- (A) Radiowaves
- (B) X-rays
- (C) Infrared waves
- (D) Ultrasound waves



27. A plane electromagnetic wave passes from air ( $n_1 = 1.0$ ) into water ( $n_2 = 1.33$ ). If absorption by water is negligible, then its reflectivity will be
- (A) 3.3% (B) 2.0%  
(C) 2.33% (D) 5.43%
28. The characteristic impedance of a transmission line is expressed as
- (A)  $\sqrt{\frac{R + j\omega L}{G + j\omega C}}$   
(B)  $\sqrt{\frac{G + j\omega C}{R + j\omega L}}$   
(C)  $\sqrt{\frac{R + j\omega C}{G + j\omega L}}$   
(D)  $\sqrt{\frac{G + j\omega L}{R + j\omega C}}$
29. The magnetic field at the center of a circular loop with radius ( $R$ ), which carries a steady current ( $I$ ) is given as
- (A)  $\frac{\mu_0 I}{R}$  (B)  $\frac{\mu_0 I}{4R}$   
(C)  $\frac{\mu_0 I}{2R}$  (D)  $\frac{\mu_0 I}{\pi R}$
30. The electrostatic pressure just outside a conductor surface is expressed as
- (A)  $P = \epsilon_0 E^2$   
(B)  $P = \frac{\epsilon_0}{2} E^2$   
(C)  $P = \epsilon_0 E$   
(D)  $P = \frac{E}{\epsilon_0}$



31. Poynting vector is expressed as

(A)  $\vec{S} = \vec{E} \times \vec{B}$

(B)  $\vec{S} = \epsilon_0 (\vec{E} \times \vec{B})$

(C)  $\vec{S} = \mu_0 (\vec{E} \times \vec{B})$

(D)  $\vec{S} = \frac{1}{\mu_0} (\vec{E} \times \vec{B})$

32. When a charge particle (with  $3 \times 10^{-19}$  Coulomb charge and  $3 \times 10^8$  m/s velocity) enters perpendicular to magnetic field of 1 Tesla, then the magnetic force will be

(A)  $9 \times 10^{11}$  Newton

(B)  $1 \times 10^{27}$  Newton

(C)  $9 \times 10^{-11}$  Newton

(D)  $3 \times 10^{-11}$  Newton

33. If in an electromagnetic wave  $\vec{E}$  and  $\vec{B}$  are in phase and mutually perpendicular, then their (real) amplitude are related as

(A)  $\vec{B}_0 = \frac{1}{c} \vec{E}_0$

(B)  $\vec{B}_0 = c \vec{E}_0$

(C)  $\vec{B}_0 = c^2 \vec{E}_0$

(D)  $\vec{B}_0 = \frac{1}{c^2} \vec{E}_0$

34. If a charged particle (with charge =  $q$ ) is accelerated with a voltage ( $V$ ) enters perpendicular to the magnetic field ( $B$ ), then the radius of the circular path of the charged particle is

(A)  $r = \frac{1}{B} \sqrt{\frac{2mV}{q}}$

(B)  $r = \frac{1}{B} \sqrt{\frac{2mq}{V}}$

(C)  $r = B \sqrt{\frac{2mV}{q}}$

(D)  $r = B \sqrt{\frac{2mq}{V}}$



35. In SI system, the unit of angular momentum is

- (A) J.s (B) J/s  
(C) J (D) W

36. For Ladder operator

- i.  $[a, a^\dagger] = 0$   
ii.  $[a, a^\dagger] = 1$   
iii.  $[a^\dagger a, a^\dagger] = a^\dagger$   
iv.  $[a^\dagger a, a] = -a$

Choose the correct statement.

- (A) Only i and ii are true  
(B) Only ii and iii are true  
(C) Only iii and iv are true  
(D) Only ii, iii and iv are true

37. For a hydrogen atom, 1s state wave function is given by

$$\psi_{1s} = N \exp\left(-\frac{r}{a_0}\right).$$

The value of N is

- (A)  $\sqrt{\frac{x}{a_0^3}}$  (B)  $\frac{1}{\sqrt{\pi a_0^3}}$   
(C)  $\pi$  (D) 1

38. The Raising and Lowering operators for simple harmonic oscillators are

- (A) Hermitian  
(B) Commutative  
(C) Non-commutative  
(D) Inverse

39. If  $\sigma$  is the Dirac matrices, then  $\sigma_x \sigma_y =$

- (A)  $\Sigma^2$  (B)  $\Sigma_x$   
(C)  $i \Sigma_z$  (D)  $i \Sigma_{xy}$

40. The spin (s) of the Dirac particle is

- (A)  $s = \frac{1}{2}$  (B)  $s = \frac{1}{2} \hbar$   
(C)  $s = \hbar \Sigma$  (D)  $s = \frac{1}{2} \hbar \Sigma$

41. Which of the following equation is known as Klein-Gorden equation ?

- (A)  $\frac{1}{c^2} \frac{\partial^2 \psi}{\partial t^2} - \nabla^2 \psi + \left( \frac{mc}{\hbar} \right)^2 \psi = 0$   
(B)  $\frac{1}{c^2} \frac{\partial^2 \psi}{\partial t^2} - \nabla^2 \psi + \left( \frac{mc}{\hbar} \right)^2 \psi = E\psi$   
(C)  $\frac{1}{c^2} \frac{\partial^2 \psi}{\partial t^2} - \nabla^2 \psi - \left( \frac{mc}{\hbar} \right)^2 \psi = 0$   
(D)  $\frac{1}{c^2} \frac{\partial^2 \psi}{\partial t^2} - \nabla^2 \psi - \left( \frac{mc}{\hbar} \right)^2 \psi = E\psi$

42. \_\_\_\_\_ perturbation theory is used to represent v and w of perturbed Hamiltonian in terms of unperturbed eigenfunctions  $u_m$  and eigenvalues  $E_m$ .

- (A) Schrodinger  
(B) Schrodinger-Dirac  
(C) Klein-Gorden  
(D) Rayleigh-Schrodinger

43. If  $\vec{L}$  is the angular momentum given by  $\vec{L} = L_x \hat{i} + L_y \hat{j} + L_z \hat{k}$ , the value of  $\vec{L} \times \vec{L}$  is

- (A)  $i\hbar L$  (B)  $i\hbar L_z$   
(C)  $L_z$  (D) Zero





44. If five non-interacting fermions have to be adjusted in first excited state of 1D-harmonic oscillator of angular frequency  $\omega$ , then the total energy of the system is
- (A)  $\frac{5\hbar\omega}{2}$  (B)  $\frac{11\hbar\omega}{2}$   
(C)  $\frac{15\hbar\omega}{2}$  (D)  $\frac{10\hbar\omega}{2}$
45. Every matrix representative of a component  $J$  which satisfies relation  $J \times J = iJ$  have
- (A) zero trace  
(B) non-zero trace  
(C) non-zero, but positive trace  
(D) unit trace
46. A system consists of  $10^{24}$  atoms and is at a temperature of 300 K. Assuming that there is no interatomic energy in the system, its total internal energy is
- (A) 12.4 J (B) 12.4 kJ  
(C) 4.12 kJ (D) 4.12 J
47. A heat pump working on Carnot cycle maintains the inside temperature of a house at  $22^\circ\text{C}$  by supplying 450 kJ/s. If the outside temperature is  $0^\circ\text{C}$ , the heat taken in kJ/s from the outside air is approximately
- (A) 487 (B) 417  
(C) 470 (D) 467
48. An oil bath kept at  $27^\circ\text{C}$  is being supplied heat at the rate of  $100 \text{ JS}^{-1}$ . Assuming the process to be quasi-static, the rate of increase of entropy of the system is approximately
- (A)  $0.33 \text{ JK}^{-1}\text{S}^{-1}$  (B)  $0.33 \text{ JK}^{-1}\text{S}^{-2}$   
(C)  $3.7 \text{ JK}^{-1}\text{S}^{-2}$  (D)  $3.7 \text{ JK}^{-1}\text{S}^{-1}$



49. For an energy state  $E$  of a photon gas, the density of state is proportional to
- (A)  $E$  (B)  $E^2$   
(C)  $\sqrt{E}$  (D)  $E^{3/2}$
50. At high temperature, entropy of spin half system is equal to
- (A)  $\frac{NK}{2}$  (B)  $2NK$   
(C)  $NK$  (D)  $NK/\ln 2$
51. Which statistics would be appropriate for the description of density of electrons and holes in semiconducting Ge at room temperature (Ge bandgap  $\sim 1$  eV) ?
- (A) Classical Maxwell-Boltzmann statistics  
(B) Fermi-Dirac statistics  
(C) Bose-Einstein statistics  
(D) It can be described by both Fermi-Dirac statistics and Bose-Einstein statistics
52. A white-dwarf star is thought to constitute a degenerate gas system at a uniform temperature much below the Fermi temperature. This system is stable against gravitational collapse so long as the electrons are
- (A) Relativistic  
(B) Non-relativistic  
(C) Relativistic as well as Non-relativistic  
(D) Independent of velocity
53. Value of fugacity,  $z$  of boson gas can take any value
- (A) between 0 and 1  
(B) above 1  
(C) below zero  
(D) between 0 and  $\infty$

54. The ground state energy  $E_0$  of the system in terms of the Fermi energy  $E_F$  and the number of electrons  $N$  is given by

(A)  $\frac{1}{2}NE_F$

(B)  $\frac{5}{3}NE_F$

(C)  $\frac{3}{5}NE_F$

(D)  $\frac{1}{3}NE_F$

55. Consider a photon gas enclosed in a volume  $V$  and in equilibrium at temperature  $T$ . How the number of photons in the volume depends upon the temperature ?

(A)  $T^3$

(B)  $T^2$

(C)  $T$

(D)  $\frac{1}{T}$

56. A one dimensional quantum harmonic oscillator (whose ground state energy is  $\hbar\omega/2$ ) is in thermal equilibrium with a heat bath at temperature  $T$ . What is the partition function ?

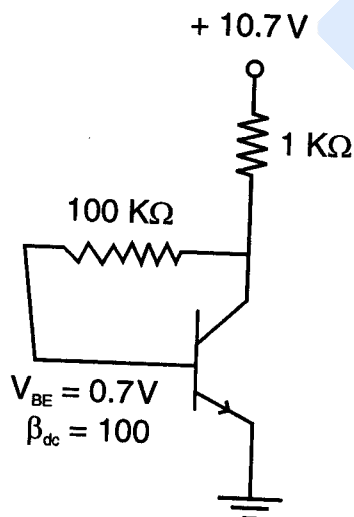
(A)  $z = \sinh(\hbar\omega/2)$

(B)  $z = 2/\sinh(\hbar\omega/2)$

(C)  $z = \cosh(\hbar\omega/2)$

(D)  $z = 2/\cosh(\hbar\omega/2)$

57. The collector current in the circuit given below is



(A)  $5\text{ mA}$

(B)  $0.5\text{ mA}$

(C)  $1\text{ mA}$

(D)  $10\text{ mA}$

58. Voltage gain and lower 3 dB cut-off frequency of a basic amplifier are 60 dB and 1.0 KHz respectively. If 10% negative feedback is introduced in the basic amplifier, then the lower 3 dB cut-off frequency of the negative feedback amplifier will be

- (A) 60 Hz (B) 11 Hz  
(C) 1.1 KHz (D) 9.9 Hz

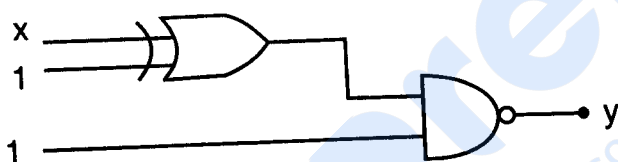
59. The number of minterms that can be generated by  $n$  variables is equal to

- (A)  $n$  (B)  $2^{n-1}$   
(C)  $2^n$  (D)  $2^{n+1}$

60. Simplified expression for the Boolean function  $F = B'C' + ABC + BC'$  is

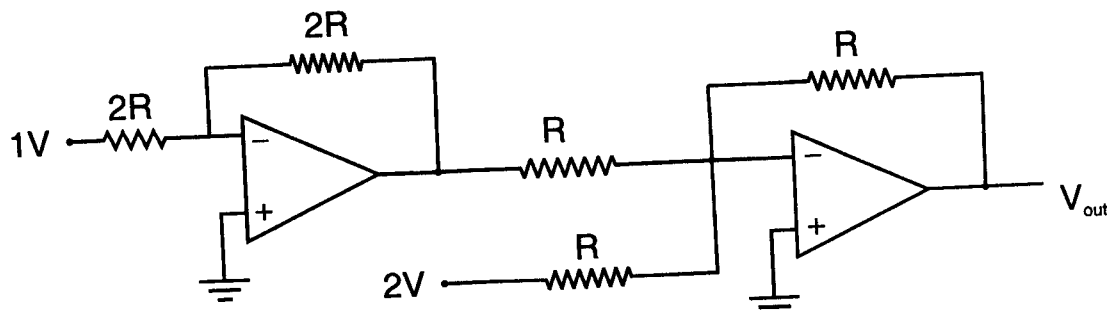
- (A)  $C + AB$  (B)  $C' + AB$   
(C)  $C' + AB'$  (D)  $C + A'B$

61. In the following circuit the output ( $y$ ) is equal to



- (A)  $x'$  (B)  $x$  (C)  $0$  (D)  $1$

62. The output voltage ( $V_{out}$ ) in the network given below is



- (A)  $2V$  (B)  $3V$  (C)  $-1V$  (D)  $-2V$



63. How many Flip-Flops are required for the fabrication of a BCD ripple counter ?  
(A) 1 (B) 2 (C) 3 (D) 4
64. Which type of sensor is used in metal detectors ?  
(A) Inductive (B) Resistive  
(C) Capacitive (D) Optical
65. Phase sensitive detector in lock-in-amplifier is also known as  
(A) Voltage controlled oscillator (B) Amplifier  
(C) Multiplier (D) Filter detector
66. In 8085 microprocessor the accumulator is a  
(A) 9-bit register (B) 7-bit register  
(C) 8-bit register (D) 6-bit register
67. If a RC network provide a phase shift of  $45^\circ$ , then how many such RC networks are required in the positive feedback section of phase shift oscillator ?  
(A) 3 (B) 4  
(C) 2 (D) 6
68. If the principal quantum number and the azimuthal quantum number in relativistic model of the atom are 3 and 1 respectively, then the magnitude of semi-minor axis  $b$  in terms of the semi-major axis  $a$  is given by  
(A)  $b = \frac{a}{3}$  (B)  $b = \frac{2}{3}a$   
(C)  $b = \frac{a}{2}$  (D)  $b = a$
69. For an atom in the state of  $^2d_{5/2}$ , the Lande g-factor should be  
(A) 2 (B) 1.20  
(C) 1.75 (D) 1.33



70. The spectral term for  $L = 2$  and  $S = 1$  is given by

- (A)  $^3d_3$  (B)  $^3d_{5/2}$   
 (C)  $^1d_{7/2}$  (D)  $^2d_5$

71. The degeneracies of the s-states arising from the 3p term with spin orbital interaction are

- (A) 1, 2, 3 (B) 3, 5, 7  
 (C) 2, 6, 10 (D) 1, 3, 5

72. The linear Stark-effect is possible in a hydrogen atom but not in a sodium atom because

- (A) The principal quantum number for the ground state of the sodium atom is different from that of the hydrogen atom in the ground state  
 (B) The principal quantum number for the ground state of the sodium atom is same as that of the hydrogen atom in ground state  
 (C) The Azimuthal quantum number for the ground state of the sodium atom is same as that of the hydrogen in ground state  
 (D) (B) and (C) both are true

73. In the presence of a weak magnetic field, atomic hydrogen undergoes the transition

$^2P_{1/2} \rightarrow ^1S_{1/2}$ , by emission of radiation. The spectral line corresponding to the transition

$$^2P_{1/2} \left( m_j = +\frac{1}{2} \right) \rightarrow ^1S_{1/2} \left( m_j = -\frac{1}{2} \right)$$

is observed along the direction of the applied magnetic field. The emitted electromagnetic field is

- (A) circularly polarized  
 (B) linearly polarized  
 (C) unpolarized  
 (D) not emitted along the magnetic field direction





74. In the microwave spectrum of identical rigid diatomic molecules, the separation between the spectral lines is recorded to be  $0.7143 \text{ cm}^{-1}$ . The moment of inertia of the molecule, in  $\text{Kg-m}^2$  is
- (A)  $2.3 \times 10^{-36}$  (B)  $2.3 \times 10^{-40}$   
 (C)  $7.8 \times 10^{-42}$  (D)  $7.8 \times 10^{-46}$
75. In a Raman scattering experiment, light of frequency  $\nu$  from a laser is scattered by diatomic molecules having the moment of inertia  $I$ . The typical Raman shifted frequency depends on
- (A)  $\nu$  and  $I$  (B) Only  $\nu$   
 (C) Only  $I$  (D) Neither  $\nu$  nor  $I$
76. A laser beam emerging from a laser tube operating at  $80 \text{ nm}$  has a cross-sectional diameter of  $2 \text{ mm}$ . The diameter of the beam at a distance of  $1 \text{ km}$  is approximately given by
- (A)  $10 \text{ mm}$  (B)  $8 \text{ cm}$   
 (C)  $80 \text{ cm}$  (D)  $10 \text{ m}$
77. The molecular spectra of two linear molecules  $\text{O} - \text{C} - \text{O}$  and  $\text{O} - \text{C} - \text{S}$  are recorded in the microwave region. Which of the following statement is correct ?
- (A) Both the molecules would show absorption lines.  
 (B) Both the molecules would not show absorption lines.  
 (C)  $\text{O} - \text{C} - \text{O}$  would show absorption lines but not  $\text{O} - \text{C} - \text{S}$ .  
 (D)  $\text{O} - \text{C} - \text{S}$  would show absorption lines but not  $\text{O} - \text{C} - \text{O}$ .
78. The quantum numbers of two electrons in a two valence electron atoms are given in table
- |           |           |                     |
|-----------|-----------|---------------------|
| $n_1 = 6$ | $l_1 = 3$ | $s_1 = \frac{1}{2}$ |
| $n_2 = 5$ | $l_2 = 1$ | $s_2 = \frac{1}{2}$ |
- Assuming J-J coupling the possible values of  $J$  are
- (A)  $0, 1, 2, 3, 4$  (B)  $0, 2, 3, 4, 5$   
 (C)  $1, 2, 3, 4, 5$  (D)  $0, 1, 2, 5, 6$



79. The potential energy of a diatomic molecule in terms of interatomic distance  $R$  is given by  $U(R) = -\frac{A}{R^m} + \frac{B}{R^n}$

where  $A$ ,  $B$ ,  $m$  and  $n$  are constant characteristics for the  $MX$ -molecules. The potential energy  $U(R)$  is minimum at  $R = R_0$  for

(A)  $n < m$

(B)  $n > m$

(C)  $n = m$

(D)  $n = 2m$

80. Concentration of Schottky imperfections in an ionic solid at a certain temperature  $T$  is given by

(Here  $E_p$  is the energy (in eV) required to remove an ion pair and other symbols have usual meaning.)

(A)  $n = -N \exp \left( \frac{E_p}{2KT} \right)$

(B)  $n = -N \exp \left( -\frac{E_p}{2KT} \right)$

(C)  $n = N \exp \left( -\frac{E_p}{2KT} \right)$

(D)  $n = \exp \left( -\frac{E_p}{2KT} \right)$

81. The energy of an edge dislocation is approximately given by

(A)  $E \approx IGb^2$

(B)  $E \approx \sqrt{IGb^2}$

(C)  $E \approx (1-\nu)/IGb^2$

(D)  $E \approx \frac{IGb^2}{1-\nu}$



82. The maximum allowed frequency  $(\omega)_{\max}$  for acoustic branch in a one dimensional diatomic lattice with force constant  $K$  is independent of lighter mass and given by
- (A)  $2K/M$  (B)  $2M/K$   
 (C)  $(2K/M)^{1/2}$  (D)  $(2M/K)^{1/2}$
83. The first order Bragg's maximum of electron diffraction in a nickel crystal ( $d = 0.4086 \text{ \AA}$ ) is found to occur at a glancing angle of  $65^\circ$ . What is the velocity of electrons ?
- (A)  $980.4 \times 10^6 \text{ m/s}$   
 (B)  $98.4 \times 10^6 \text{ m/s}$   
 (C)  $9.84 \times 10^6 \text{ m/s}$   
 (D)  $0.984 \times 10^6 \text{ m/s}$
84. Using the tight binding model, energy-wave vector dispersion relation for a one dimensional crystal of lattice parameter 'a' is given by  $E(\vec{K}) = E_0 - \alpha - 2\beta \cos Ka$ . What is the value of effective mass of electron  $m^*$  in terms of  $K$  ?
- (A)  $\hbar^2/2\alpha^2\beta \sin Ka$   
 (B)  $\hbar^2/2\alpha\beta \sin Ka$   
 (C)  $\hbar^2/2\alpha\beta \cos Ka$   
 (D)  $\hbar^2/2\alpha^2\beta \cos Ka$
85. The Kronig-Penny potential with  $P \ll 1$ , the energy of the lowest band at  $K = 0$  is
- (A)  $4\pi^2 ma/h^2P$   
 (B)  $h^2P/4\pi^2 ma$   
 (C)  $4\pi^2 mP/h^2a$   
 (D)  $h^2a/4\pi^2 mP$



86. In a Hall effect experiment, a germanium crystal of length 0.2 cm, breadth 0.12 cm and thickness 0.22 cm is used. When a potential of 1.0 V is applied, a current of 2.5 mA flows along x-direction. When a magnetic field of 0.5 Tesla is applied along z-direction, a Hall voltage of 1.0 mV is found to develop. What is concentration of charge carriers ?
- (A)  $6.5 \times 10^{20}/\text{m}^3$   
(B)  $65 \times 10^{20}/\text{m}^3$   
(C)  $0.65 \times 10^{20}/\text{m}^3$   
(D)  $0.065 \times 10^{20}/\text{m}^3$
87. The critical magnetic field for aluminium is  $7.9 \times 10^3$  A/m. What is the critical current which can flow through a long thin superconducting wire of aluminium of diameter  $10^{-4}$  m ?
- (A) 0.248A  
(B) 20.48A  
(C) 200.48A  
(D) 2.48A
88. When a metal enters the superconducting state, it
- (A) becomes ordered and its free energy decreases  
(B) becomes ordered and its free energy increases  
(C) becomes disordered and its free energy decreases  
(D) becomes disordered and its free energy increases
89. The number of point groups in a 2-dimensional crystal system is
- (A) 5  
(B) 10  
(C) 15  
(D) 20



90. The asymmetry term in the Weizsacker's semi-empirical mass formula is because of
- (A) non-spherical shape of the nucleus
  - (B) non-zero spin of nucleus
  - (C) unequal number of protons and neutrons inside the nucleus
  - (D) odd number of protons inside the nucleus
91. According to nuclear shell model which includes spin orbit coupling, the spin and parity of the ground state of  ${}_5\text{B}^{11}$  is
- (A)  $\frac{3^-}{2}$
  - (B)  $\frac{3^+}{2}$
  - (C)  $\frac{1^-}{2}$
  - (D)  $\frac{1^+}{2}$
92. Arrange the following fundamental forces of nature in increasing order of their magnitude.
- 1. Weak
  - 2. Strong
  - 3. Gravitational
  - 4. Electromagnetic
- (A) 3, 2, 4, 1
  - (B) 3, 1, 4, 2
  - (C) 2, 4, 3, 1
  - (D) 2, 1, 4, 3
93. What must be the temperature of the gas of deuterons if the average kinetic energy of the deuterons has to be greater than the estimated barrier height ? (Barrier potential height  $B = 350 \text{ KeV}$ ) (Boltzmann constant  $K = 1.38 \times 10^{-23} \text{ J/K}$ )
- (A)  $10^6 \text{ K}$
  - (B)  $0 \text{ K}$
  - (C)  $10^9 \text{ K}$
  - (D)  $10^3 \text{ K}$



94. Choose the particle with zero baryon number from the option given below.

(A) Proton

(B) Neutron

(C) Pion

(D)  $\Delta^+$

95. The correct matching pair of reaction with the conservation quantity is

(A)  $P \rightarrow e^+ + \nu_e$       Baryon number

(B)  $P \rightarrow e^+ + \bar{\nu}_e$       Lepton number

(C)  $n + \pi^+ \rightarrow \pi^- + P$       Charge

(D)  $n + \pi^+ \rightarrow \pi^0 + P$       Baryon number

96. The rate of energy loss by ionisation of a relativistic charged particle travelling through the matter is

(A) inversely proportional to its energy

(B) independent of energy

(C) proportional to its energy

(D) none of the above

97. A pion at rest decays into muon and neutrino  $\pi \rightarrow \mu + \nu$ . The relativistic velocity of muon ( $\mu$ ) in terms of  $m_\pi$  and  $m_\mu$  is given by

(A)  $\left( \frac{m_\pi^2 + m_\mu^2}{m_\pi^2 - m_\mu^2} \right) c$

(B)  $\left( \frac{m_\pi^2 - m_\mu^2}{m_\pi^2 + m_\mu^2} \right) c$

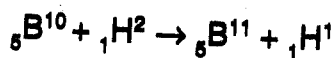
(C)  $\left( \frac{m_\pi^2}{m_\mu^2} \right) c$

(D)  $\left( \frac{m_\mu^2}{m_\pi^2} \right) c$





98. Calculate the energy released in MeV from the nuclear reaction.



$$m({}_6\text{B}^{10}) = 10.01605 \text{ U}$$

$$m({}_6\text{B}^{11}) = 11.01286 \text{ U}$$

$$m({}_1\text{H}^2) = 2.01472 \text{ U}$$

$$m({}_1\text{H}^1) = 1.00812 \text{ U}$$

(A) 19.114 MeV

(B) 9.114 MeV

(C) 0.009 MeV

(D) 12.021 MeV

99. The two nuclei can fuse together to form a helium nucleus (radius of deuterium nucleus  $r_0 = 1.5 \times 10^{-15} \text{ m}$  (approx.)). Find the potential energy (V) of repulsion between two nuclei.

(A)  $0.88 \times 10^{-11} \text{ Joule}$

(B)  $0.77 \times 10^{-13} \text{ Joule}$

(C)  $0.66 \times 10^{-10} \text{ Joule}$

(D)  $0.155 \times 10^{15} \text{ Joule}$

100. Calculate the mass of an electron accelerated to a kinetic energy of 2 MeV.

$$(m_0 = 9.1 \times 10^{-31} \text{ kg})$$

(A)  $9.111 \times 10^{-31} \text{ kg}$

(B)  $35.555 \times 10^{-31} \text{ kg}$

(C)  $8.890 \times 10^{-31} \text{ kg}$

(D)  $44.655 \times 10^{-31} \text{ kg}$



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