

Signature of Invigilators

1.

Roll No.

(In figures as in Admit Card)

2.

Paper III

Roll No.

J—0202

Name of Areas/Section (if any)

Time Allowed : $2\frac{1}{2}$ Hours]

[Maximum Marks : 200

Instructions for the Candidates

1. Write your Roll number in the space provided on the top of this page.
2. Write name of your Elective/Section if any.
3. Answer to short answer/essay type questions are to be written in the space provided below each question or after the questions in test booklet itself. No additional sheets are to be used.
4. Read instructions given inside carefully.
5. Last page is attached at the end of the test booklet for rough work.
6. If you write your name or put any special mark on any part of the test booklet which may disclose in any way your identity, you will render yourself liable to disqualification.
7. Use of any calculator is prohibited.
8. There is no negative marking.
9. You should return the test booklet to the invigilator at the end of the examination and should not carry any paper outside the examination hall.

પરીક્ષાર્થીઓ માટેની સૂચનાઓ :

1. આ પાનાની ટોચમાં દર્શાવેલી જગ્યામાં તમારો રોલ નંબર લખો.
2. જો કોઈ વિકલ્પ/વિભાગ પસંદ કર્યા હોય તો તે પોત્ય જગ્યાએ દર્શાવો.
3. ટુકડો/નિબંધ વિષેના જવાબો એ પ્રશ્નની નીચે અગાર બાજુમાં આપેલી જગ્યામાં લખો. વધારાના કોઈ પાનાનો ઉપયોગ કરશો નહીં.
4. અંદર આપેલી સૂચનાઓ કાળજીપૂર્વક વાંચો.
5. બુકલેટની પાછળ આપેલું છેલ્લું પાનું રફ કામ માટે છે.
6. બુકલેટ કોઈપણ ઠેકણો તમારું નામ કે કોઈ ચોક્કસ સંદર્ભ કરવી નહીં કે જે તમારી ઓળખ પૂરી પાડે. આ તમને પરીક્ષા માટે ગેરલાયક ઠેરવશે.
7. કેલ્ક્યુલેટર નો ઉપયોગ કરાશો નહીં.
8. નકારાત્મક માર્કિંગ નથી.
9. પરીક્ષા સમય પૂરો થઈ ગયા પછી આ બુકલેટ જે તે નીરીકણને સોંપી દેવી. કોઈપણ પેપર પરીક્ષા રૂમની બાહર લઈ જવું નહીં.

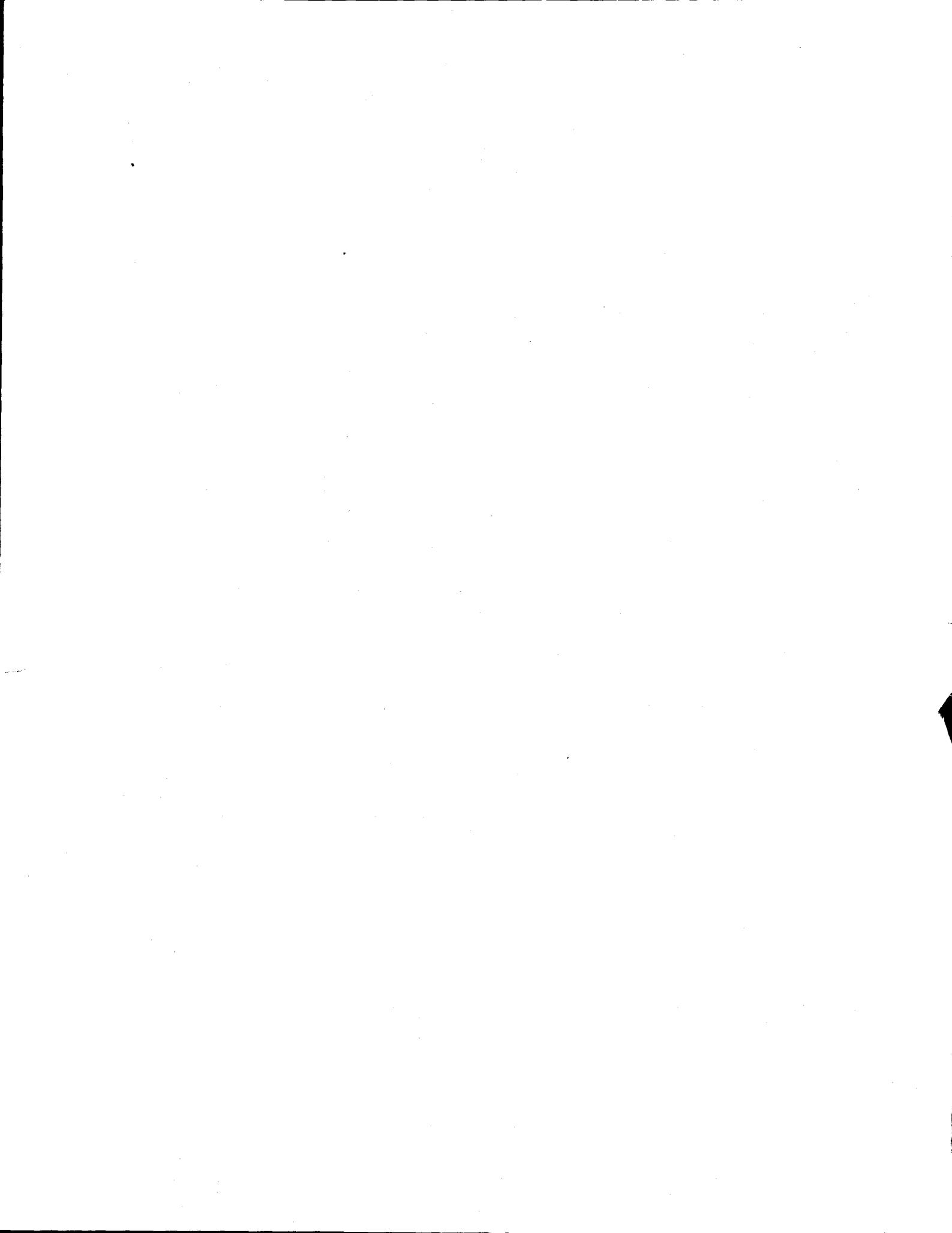
FOR OFFICE USE ONLY Marks Obtained

Question Number	Marks Obtained	Question Number	Marks Obtained	Question Number	Marks Obtained
1	26				
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					

Total Marks Obtained.....

Signature of the co-ordinator.....

(Evaluation)



PHYSICAL SCIENCES
PAPER III

- Note :—(i)* Part A consists of 10 questions of 10 marks each. Attempt each question in about 200 words (2 pages). All questions are compulsory.
- (ii)* Part B consists of 16 questions of 25 marks each. Attempt any four questions from Part B. Each question is to be answered in about 500 words (5 pages).
- (iii)* Log tables be allowed, but not a calculator.

PART A

1. $f(x) = x^2$ over $-\pi < x < \pi$.

Expand $f(x)$ in the form of Fourier Series, and using it show that :

$$\sum_{n=1}^{\infty} \frac{(-1)^{n+1}}{n^2} = \frac{\pi^2}{12}.$$

2. Evaluate the following, using contour integration

$$\int_0^{\infty} \frac{x^{1/2}}{1+x^2} dx$$

3. The kinetic and potential energies of a conservative system are :

$$T = \frac{1}{2} M \dot{x}^2 + \frac{m(\dot{x}^2 + l^2 \dot{\theta}^2 + 2l \dot{x} \dot{\theta} \cos \theta)}{2}$$

$$V = -mg l \cos \theta.$$

Obtain the Lagrange's equations of the system.

4. A particle of mass 2 kg moving with a speed of 3 m/s hits another particle of mass 4 kg headon. The collision is perfectly elastic. Find the final speeds of the two particles.
5. A charged particle moving with a uniform velocity $4\hat{i}$ m/s in the region where $\vec{E} = 20\hat{j}$ V/m and $\vec{B} = B_0\hat{k}$ tesla. Determine B_0 such that the velocity of the particle remains constant.

6. A large number of particles N are distributed in two levels with energy

$$E_1 = -\epsilon/2$$

$$E_2 = +\epsilon/2.$$

Obtain the expression for entropy of such a system as a function of total energy of the system. At what energy is the entropy maximum ?

7. Using the Uncertainty Principle, show that a particle in an infinite square well potential will have finite kinetic energy.
8. Describe Laue's, rotating crystal, and powder methods of X-ray diffraction. What additional information, if any, one can obtain if one carries out neutron diffraction experiment ?
9. Obtain the expression for reflection coefficient for a beam of particles coming from $-\infty$ and incident on a potential step given by :

$$V(x) = 0 \text{ for } x < 0$$

$$V(x) = V_0 \text{ for } x > 0$$

[Kinetic energy of particles is larger than V_0 for $x < 0$].

10. Discuss briefly the measurement of energy and time using electronic signals.

PART B

11. (a) Explain energy band diagram of an open-circuit PN junction. Show that the contact difference of potential of the PN junction is given by

$$kT \ln \frac{N_D N_A}{n_i^2},$$

where N_D , N_A and n_i are donor, acceptor and intrinsic carrier concentrations respectively.

- (b) What are the four possible topologies of a feedback amplifier ? Identify the output signal and the feedback signal for each topology.
12. (a) What is a comparator circuit ? How does it differ from a clipping circuit ? Draw the circuit of a diode comparator and its output waveform.
- (b) Explain how to modify a ripple counter so that it divides by N, where N is not a power of 2.

13. (a) Using OPAMs, develop a suitable block diagram of an electronic analog computer to program the differential equation

$$\frac{d^2V}{dt^2} + k_1 \frac{dV}{dt} + k_2 V - v_1 = 0$$

where v_1 is a function of time, k_1 and k_2 are real positive constants.

- (b) Prove the Boolean identity

$$A + BC = (A + B)(A + C).$$

(c) Why do we use, at times, D/A converter for realizing A/D converter ?

14. (a) Explain the function of a master-slave J-K flip-flop. How is race around condition eliminated in it ?

(b) Explain briefly the function of a four stage ring counter.

(c) Explain the function of a full adder. How many half adders are required to implement it ?

15. Elaborate the difference between spontaneous and stimulated emissions. Why is stimulated emission used for lasing action ? Explain why population inversion is necessary but not sufficient for a laser ?

16. Discuss the basic principle of NMR. For a magnetic field of 1.5 Tesla, what will be the resonance frequency ? Distinguish between spin-spin and spin-lattice relaxation. Give a block diagram of NMR spectrometer, giving description of each block. [Given : $\mu = 1.41 \times 10^{-30}$ J/gauss]

17. What is London interaction ? Prove that the total potential energy of two atoms at separation R in a weakly bonded solid is

$$U(R) = 4 \epsilon \left[(\sigma / R)^{12} - (\sigma / R)^6 \right].$$

18. Describe Stern-Gerlach experiment for silver atoms. If we use a beam of carbon atoms, how many different beams will emerge ?

19. Describe the Hall effect experiment for a metal having one type of charge carriers. Obtain an expression for the Hall coefficient in terms of charge carrier concentration.

A rectangular block of monoatomic metal of dimensions 2 cm \times 3 cm \times 4 cm is used for the Hall effect experiment. Constant current of 25 amp. is

- allowed to flow normal to one face of the block, and a magnetic field of 1 Tesla is applied normal to another face. Which faces should be chosen for obtaining maximum Hall voltage ?
20. Distinguish between metals, semiconductors, insulators and superconductors. Describe how Brillouin zone helps to understand diffraction phenomena in crystal lattices. Show that for a square two-dimensional lattice, the kinetic energy of free electron at a corner of the first Brillouin zone is higher than that of electron at the midpoint of side-face of the zone by a factor 2.
21. What are different sources of polarizability of a solid ? Prove that the electric field at the site of an atom in the solid is greater than the external field by a factor proportional to the polarization density.
22. Describe the tight binding method for calculation of band structure. Obtain an expression of the energy band in a simple cubic solid using this particular method. Assume nearest neighbour interactions only.
23. Explain the terms :
(i) secular equilibrium;
(ii) transient equilibrium.
Obtain relevant equations and discuss the necessary conditions.
24. Give the evidence for nuclear shell structure, and explain the detailed structure of nucleus using single particle shell model. What are its limitations ?
25. What do you understand by Q-value of nuclear reaction ? Discuss the compound nucleus theory of nuclear reactions. Give the experimental evidence in support of the theory.
26. Discuss the classification of elementary particles in various families. Why is it necessary to introduce strangeness quantum number ?

ANTILOGARITHMS

ANTILOGARITHMS

	0	1	2	3	4	5	6	7	8	9	123	4	5	6	7	8	9	
-50	3162	3170	3177	3184	3192	3199	3206	3214	3221	3228	112	3	4	5	6	7	8	
-51	3236	3243	3251	3258	3266	3273	3281	3289	3296	3304	112	3	4	5	6	7	8	
-52	3311	3319	3327	3334	3342	3350	3357	3365	3373	3381	112	3	4	5	6	7	8	
-53	3388	3396	3404	3412	3420	3428	3436	3443	3451	3459	112	3	4	5	6	7	8	
-54	3467	3475	3483	3491	3499	3508	3516	3524	3532	3540	112	3	4	5	6	7	8	
-55	3554	3556	3558	3565	3573	3581	3589	3597	3606	3614	3622	112	3	4	5	6	7	8
-56	3631	3639	3648	3656	3664	3673	3681	3690	3698	3707	113	3	4	5	6	7	8	
-57	3715	3724	3733	3741	3750	3758	3767	3776	3784	3793	113	3	4	5	6	7	8	
-58	3802	3811	3819	3828	3837	3846	3855	3864	3873	3882	113	3	4	5	6	7	8	
-59	3890	3899	3908	3917	3926	3936	3945	3954	3963	3972	113	3	4	5	6	7	8	
-60	3981	3990	3999	4009	4018	4027	4036	4046	4055	4064	113	3	4	5	6	7	8	
-61	4074	4083	4093	4102	4111	4121	4130	4140	4150	4159	112	3	4	5	6	7	8	
-62	4169	4178	4187	4196	4207	4217	4227	4236	4246	4256	112	3	4	5	6	7	8	
-63	4266	4266	4276	4285	4295	4305	4315	4325	4335	4345	112	3	4	5	6	7	8	
-64	4365	4375	4385	4395	4406	4416	4426	4436	4446	4457	112	3	4	5	6	7	8	
-65	4467	4477	4487	4498	4508	4519	4529	4539	4549	4559	112	3	4	5	6	7	8	
-66	4571	4581	4592	4603	4613	4624	4634	4645	4656	4667	112	3	4	5	6	7	8	
-67	4677	4688	4699	4710	4721	4732	4742	4753	4764	4775	112	3	4	5	6	7	8	
-68	4766	4797	4808	4819	4831	4842	4853	4864	4875	4887	112	3	4	5	6	7	8	
-69	4888	4909	4920	4932	4943	4953	4966	4977	4989	4999	112	3	4	5	6	7	8	
-70	5012	5023	5035	5047	5058	5070	5082	5093	5105	5117	112	4	5	6	7	8	9	
-71	5129	5140	5152	5164	5176	5188	5200	5212	5224	5236	112	4	5	6	7	8	9	
-72	5248	5260	5272	5284	5297	5309	5321	5333	5345	5358	112	4	5	6	7	8	9	
-73	5370	5383	5395	5408	5420	5433	5445	5458	5470	5483	112	4	5	6	7	8	9	
-74	5495	5508	5521	5534	5546	5559	5572	5585	5598	5610	112	3	4	5	6	7	8	
-75	5623	5636	5649	5662	5675	5689	5702	5715	5728	5741	112	3	4	5	6	7	8	
-76	5754	5768	5781	5794	5808	5821	5834	5848	5861	5875	112	3	4	5	6	7	8	
-77	5888	5902	5916	5929	5943	5957	5970	5984	5998	6012	112	3	4	5	6	7	8	
-78	6026	6039	6053	6067	6081	6095	6109	6124	6138	6152	112	3	4	5	6	7	8	
-79	6166	6180	6194	6209	6223	6237	6251	6266	6281	6295	112	3	4	5	6	7	8	
-80	6310	6324	6339	6353	6368	6383	6397	6412	6427	6442	112	3	4	5	6	7	8	
-81	6457	6471	6486	6501	6516	6531	6546	6561	6577	6592	112	3	4	5	6	7	8	
-82	6607	6622	6637	6653	6668	6683	6699	6714	6729	6745	112	3	4	5	6	7	8	
-83	6761	6776	6792	6808	6823	6839	6855	6871	6887	6902	112	3	4	5	6	7	8	
-84	6918	6934	6950	6966	6982	6998	7015	7031	7047	7063	112	3	4	5	6	7	8	
-85	7079	7096	7112	7129	7145	7161	7178	7194	7211	7228	112	3	4	5	6	7	8	
-86	7244	7261	7278	7295	7311	7328	7345	7362	7379	7396	112	3	4	5	6	7	8	
-87	7413	7510	7517	7547	7564	7582	7599	7616	7534	7551	112	3	4	5	6	7	8	
-88	7586	7603	7621	7638	7656	7674	7691	7709	7727	7745	112	3	4	5	6	7	8	
-89	7762	7780	7798	7816	7834	7852	7870	7889	7907	7925	112	3	4	5	6	7	8	
-90	7943	7962	7980	7998	8017	8035	8054	8072	8091	8110	112	3	4	5	6	7	8	
-91	8128	8147	8166	8185	8204	8222	8241	8260	8279	8299	112	3	4	5	6	7	8	
-92	8318	8337	8356	8375	8395	8414	8433	8453	8472	8492	112	3	4	5	6	7	8	
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-96	9120	9141	9162	9183	9204	9226	9247	9268	9289	9310	112	3	4	5	6	7	8	
-97	9333	9354	9376	9397	9419	9441	9461	9481	9502	9523	112	3	4	5	6	7	8	
-98	9550	9572	9594	9616	9638	9661	9683	9705	9727	9750	112	3	4	5	6	7	8	
-99	9772	9795	9817	9840	9863	9886	9903	9924	9945	9967	112	3	4	5	6	7	8	

LOGARITHMS

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10	0000	0043	0086	0128	0170	0212	0253	0294	0334	0374	0414	0453	0492	0531	0569	0607	0645	0682	0719	0755
11	0141	0182	0223	0264	0302	0343	0381	0421	0459	0497	0534	0571	0609	0647	0685	0723	0761	0800	0838	0876
12	0792	0833	0874	0912	0950	0988	1026	1064	1102	1140	1178	1216	1254	1292	1330	1368	1406	1444	1482	1520
13	1139	1173	1206	1239	1271	1303	1335	1367	1401	1433	1465	1497	1529	1561	1593	1625	1657	1689	1721	1753
14	1601	1632	1663	1695	1726	1757	1788	1818	1847	1875	1903	1931	1959	1987	2014	2041	2068	2095	2122	2149
15	1761	1790	1818	1847	1875	1903	1931	1959	1987	2014	2041	2068	2095	2122	2149	2177	2205	2233	2261	2289
16	2041	2068	2095	2122	2149	2177	2205	2233	2261	2289	2317	2345	2373	2401	2429	2457	2485	2513	2541	2569
17	2304	2330	2355	2380	2405	2430	2455	2480	2504	2529	2554	2580	2605	2631	2656	2682	2707	2732	2757	2783
18	2353	2377	2401	2426	2450	2475	2500	2525	2549	2574	2600	2625	2650	2675	2700	2725	2750	2775	2800	2825
19	2788	2810	2833	2856	2878	2900	2923	2945	2967	2989	3011	3033	3055	3077	3099	3121	3143	3165	3187	3209
20	3010	3032	3054	3075	3096	3118	3139	3160	3181	3201	324	326	328	330	332	334	336	338	340	342
21	3222	3243	3263	3284	3304	3324	3345	3365	3385	3404	342	344	346	348	350	352	354	356	358	360
22	3424	3444	3464	3483	3502	3522	3541	3560	3579	3598	361	363	365	367	369	371	373	375	377	379
23	3675	3694	3713	3732	3751	3770	3789	3808	3827	3846	3865	3884	3903	3922	3941	3960	3979	3998	4017	4036
24	3979	3997	4014	4031	4048	4065	4083	4099	4116	4133	4150	4167	4184	4191	4208	4225	4242	4259	4276	4293
25	4074	4091	4108	4125	4142	4159	4176	4193	4210	4227	4244	4261	4278	4295	4312	4329	4346	4363	4380	4397
26	4150	4166	4184	4201	4216	4233	4249	4265	4281	4298	4315	4332	4349	4366	4383	4390	4407	4		