Fortran Assignment 3

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Contents

1 Student Info

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2 Statement

The following programs have been compiled in root directory of this Archive. Programs compiled in their local directory are present in the local directory P1a, P1b, P2, ..., P14.

- Use emacs org-mode to compile the Assignment.org file in the root directory
- Use standard compiler in local directory

3 Problem 1a

3.1 Question

Problem-1(a)

The distance between two points (x_1, y_1) and (x_2, y_2) on a Cartesian coordinate plane is given by the equation

$$d = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$$

Write a Fortran program to calculate the distance between any two points (x1, y1) and (x2, y2) specified by the user. Use the program to calculate the distance between the points (–1,1) and (6,2).

3.2 Solution

3.2.1 Source Code

```
program P1a

    implicit none
    real :: x1, y1, x2, y2, d

    open(unit=999, status="old", file="input.dat")
    read(999, *) x1, y1
    read(999, *) x2, y2
```

```
    close(999)

    d = sqrt(((x1 - x2)**2)+((y1 - y2)**2))

    open(unit=998, status="old", file="output.dat")
    write(998, *) "Distance between the two points is ", d

end program P1a
```

3.2.2 Input File

```
cat input.dat
```

```
-1  1
 6  2
```

3.2.3 Output File

```
cat output.dat
```

```
Distance between the two points is    7.07106781
```

4 Problem 1b

4.1 Question

Problem-1(b)

Given the two points S (0, 0, 0) and T (6.25, 5.75, 3.10), write a computer program to compute and print the following:

The distance between the two points as well as the direction cosines of the vector ST along X-, Y- and Z-axis

4.2 Solution

4.2.1 Source Code

```
program P1b

    implicit none
    real :: x1, y1, z1, x2, y2, z2, d
```

```
    real :: l, m, n

    open(unit=999, status="old", file="input.dat")
    read(999, *) x1, y1, z1
    read(999, *) x2, y2, z2
    close(999)

    d = sqrt(((x1 - x2)**2)+((y1 - y2)**2)+((z1 - z2)**2))
    l = (x1 - x2)/d
    m = (y1 - y2)/d
    n = (z1 - z2)/d

    open(unit=998, status="old", file="output.dat")
    write(998, *) "Distance ", d
    write(998, *) "DC(x) ", l
    write(998, *) "DC(y) ", m
    write(998, *) "DC(z) ", n

end program P1b
```

4.2.2 Input File

```
cat input.dat
```

0	0	0
6.25	5.75	3.1

4.2.3 Output File

```
cat output.dat
```

Distance	9.04074097
DC(x)	-0.691314995
DC(y)	-0.636009812
DC(z)	-0.34289223

5 Problem 2

5.1 Question

Problem-2: Calculating Orbits

When a satellite orbits the Earth, the satellite's orbit will form an ellipse with the Earth located at one of the focal points of the ellipse. The satellite's orbit can be expressed in polar coordinates as

$$r = \frac{p}{1 - \varepsilon \cos\theta}$$

where r and θ are the distance and angle of the satellite from the center of the Earth, p is a parameter specifying the size of the orbit, and ε is a parameter representing the eccentricity of the orbit.
A circular orbit has an eccentricity ε of zero. An elliptical orbit has an eccentricity of 0 ≤ ε ≤ 1. If ε > 1, the satellite follows a hyperbolic path and escapes from the Earth's gravitational field.
Consider a satellite with a size parameter p = 1200 km. Write a program to calculate the distance of the satellite from the center of the Earth as a function of θ if the satellite has an eccentricity of (a) ε = 0; (b) ε = 0.25; (c) ε = 0.5.

Write a single program in which r and ε are both input values.

How close does each orbit come to the Earth? How far away does each orbit get from the Earth?

5.2 Solution

5.2.1 Source Code

```
program P2

    implicit none
    real, dimension(3) :: epsilon, rMax, rMin
    real :: p
    real, parameter :: pi=3.1415927
    integer :: i, j
    integer, dimension(360) :: thetaD
    real, dimension(360) :: thetaR
    real, dimension(3,360) :: r

    do i=1,360
    thetaD(i) = i-1
    thetaR(i) = (pi*real(thetaD(i)))/180.0
    end do
```

```
open(unit=999, status="old", file="input.dat")
read(999, *) p, epsilon(1), epsilon(2), epsilon(3)
close(999)

print *, "- Let MAX(r) be the maximum distance from Earth"
print *, "- Let MIN(r) be the minimum distance from Earth"

do i=1,3
do j=1,360
r(i,j) = p/(1 - (cos(thetaR(j)))*epsilon(i))
end do
end do

do i=1,3
rMax(i) = maxval(r(i,:))
rMin(i) = minval(r(i,:))
end do

open(unit=997, status="old", file="table1.dat")
write(997, *) "\theta ", "r ", "\theta ", "r ", "\theta ",
↪  "r ", "\theta ", "r "
do i=1,360,5
write(997, *) thetaD(i), r(1,i), thetaD(i+2), r(1,i+2),
↪  thetaD(i+3), r(1,i+3), thetaD(i+4), r(1,i+4)
end do

open(unit=995, status="old", file="table2.dat")
write(995, *) "\theta ", "r ", "\theta ", "r ", "\theta ",
↪  "r ", "\theta ", "r "
do i=1,360,5
write(995, *) thetaD(i), r(2,i), thetaD(i+2), r(2,i+2),
↪  thetaD(i+3), r(2,i+3), thetaD(i+4), r(2,i+4)
end do

open(unit=996, status="old", file="table3.dat")
write(996, *) "\theta ", "r ", "\theta ", "r ", "\theta ",
↪  "r ", "\theta ", "r "
do i=1,360,5
write(996, *) thetaD(i), r(3,i), thetaD(i+2), r(3,i+2),
↪  thetaD(i+3), r(3,i+3), thetaD(i+4), r(3,i+4)
```

```
    end do


    open(unit=998, status="old", file="output.dat")
    write(998, *) "\epsilon ", "MIN(r) ", "MAX(r)"
    do j=1,3
    write(998, *) epsilon(j), rMin(j), rMax(j)
    end do

end program P2
```

- Let MAX(r) be the maximum distance from Earth
- Let MIN(r) be the minimum distance from Earth

5.2.2 Input File

```
cat input.dat
```

```
1200
0
0.5
0.25
```

5.2.3 Output File

```
cat output.dat
```

ϵ	MIN(r)	MAX(r)
0.0	1200.0	1200.0
0.5	800.0	2400.0
0.25	960.0	1600.0

- $\epsilon = \mathbf{0}$

```
cat table1.dat
```

θ	r	θ	r	θ	r	θ	r
0	1200.0	2	1200.0	3	1200.0	4	1200.0
5	1200.0	7	1200.0	8	1200.0	9	1200.0
10	1200.0	12	1200.0	13	1200.0	14	1200.0

15	1200.0	17	1200.0	18	1200.0	19	1200.0
20	1200.0	22	1200.0	23	1200.0	24	1200.0
25	1200.0	27	1200.0	28	1200.0	29	1200.0
30	1200.0	32	1200.0	33	1200.0	34	1200.0
35	1200.0	37	1200.0	38	1200.0	39	1200.0
40	1200.0	42	1200.0	43	1200.0	44	1200.0
45	1200.0	47	1200.0	48	1200.0	49	1200.0
50	1200.0	52	1200.0	53	1200.0	54	1200.0
55	1200.0	57	1200.0	58	1200.0	59	1200.0
60	1200.0	62	1200.0	63	1200.0	64	1200.0
65	1200.0	67	1200.0	68	1200.0	69	1200.0
70	1200.0	72	1200.0	73	1200.0	74	1200.0
75	1200.0	77	1200.0	78	1200.0	79	1200.0
80	1200.0	82	1200.0	83	1200.0	84	1200.0
85	1200.0	87	1200.0	88	1200.0	89	1200.0
90	1200.0	92	1200.0	93	1200.0	94	1200.0
95	1200.0	97	1200.0	98	1200.0	99	1200.0
100	1200.0	102	1200.0	103	1200.0	104	1200.0
105	1200.0	107	1200.0	108	1200.0	109	1200.0
110	1200.0	112	1200.0	113	1200.0	114	1200.0
115	1200.0	117	1200.0	118	1200.0	119	1200.0
120	1200.0	122	1200.0	123	1200.0	124	1200.0
125	1200.0	127	1200.0	128	1200.0	129	1200.0
130	1200.0	132	1200.0	133	1200.0	134	1200.0
135	1200.0	137	1200.0	138	1200.0	139	1200.0
140	1200.0	142	1200.0	143	1200.0	144	1200.0
145	1200.0	147	1200.0	148	1200.0	149	1200.0
150	1200.0	152	1200.0	153	1200.0	154	1200.0
155	1200.0	157	1200.0	158	1200.0	159	1200.0
160	1200.0	162	1200.0	163	1200.0	164	1200.0
165	1200.0	167	1200.0	168	1200.0	169	1200.0
170	1200.0	172	1200.0	173	1200.0	174	1200.0
175	1200.0	177	1200.0	178	1200.0	179	1200.0
180	1200.0	182	1200.0	183	1200.0	184	1200.0
185	1200.0	187	1200.0	188	1200.0	189	1200.0
190	1200.0	192	1200.0	193	1200.0	194	1200.0
195	1200.0	197	1200.0	198	1200.0	199	1200.0
200	1200.0	202	1200.0	203	1200.0	204	1200.0
205	1200.0	207	1200.0	208	1200.0	209	1200.0
210	1200.0	212	1200.0	213	1200.0	214	1200.0

215	1200.0	217	1200.0	218	1200.0	219	1200.0
220	1200.0	222	1200.0	223	1200.0	224	1200.0
225	1200.0	227	1200.0	228	1200.0	229	1200.0
230	1200.0	232	1200.0	233	1200.0	234	1200.0
235	1200.0	237	1200.0	238	1200.0	239	1200.0
240	1200.0	242	1200.0	243	1200.0	244	1200.0
245	1200.0	247	1200.0	248	1200.0	249	1200.0
250	1200.0	252	1200.0	253	1200.0	254	1200.0
255	1200.0	257	1200.0	258	1200.0	259	1200.0
260	1200.0	262	1200.0	263	1200.0	264	1200.0
265	1200.0	267	1200.0	268	1200.0	269	1200.0
270	1200.0	272	1200.0	273	1200.0	274	1200.0
275	1200.0	277	1200.0	278	1200.0	279	1200.0
280	1200.0	282	1200.0	283	1200.0	284	1200.0
285	1200.0	287	1200.0	288	1200.0	289	1200.0
290	1200.0	292	1200.0	293	1200.0	294	1200.0
295	1200.0	297	1200.0	298	1200.0	299	1200.0
300	1200.0	302	1200.0	303	1200.0	304	1200.0
305	1200.0	307	1200.0	308	1200.0	309	1200.0
310	1200.0	312	1200.0	313	1200.0	314	1200.0
315	1200.0	317	1200.0	318	1200.0	319	1200.0
320	1200.0	322	1200.0	323	1200.0	324	1200.0
325	1200.0	327	1200.0	328	1200.0	329	1200.0
330	1200.0	332	1200.0	333	1200.0	334	1200.0
335	1200.0	337	1200.0	338	1200.0	339	1200.0
340	1200.0	342	1200.0	343	1200.0	344	1200.0
345	1200.0	347	1200.0	348	1200.0	349	1200.0
350	1200.0	352	1200.0	353	1200.0	354	1200.0
355	1200.0	357	1200.0	358	1200.0	359	1200.0

- $\epsilon = \mathbf{0.25}$

```
cat table2.dat
```

θ	r	θ	r	θ	r	θ	r
0	2400.0	2	2398.53882	3	2396.71558	4	2394.16797
5	2390.90186	7	2382.24292	8	2376.86841	9	2370.81128
10	2364.08423	12	2348.67578	13	2340.02515	14	2330.76611
15	2320.91675	17	2299.52197	18	2288.01636	19	2276.0
20	2263.49463	22	2237.10278	23	2223.26147	24	2209.02002

25	2194.40137	27	2164.12451	28	2148.51147	29	2132.61255
30	2116.44971	32	2083.42041	33	2066.59692	34	2049.59595
35	2032.43774	37	1997.72839	38	1980.2157	39	1962.6217
40	1944.9646	42	1909.52771	43	1891.78027	44	1874.03333
45	1856.30188	47	1820.93835	48	1803.3324	49	1785.79272
50	1768.33057	52	1733.67993	53	1716.51099	54	1699.45825
55	1682.52966	57	1649.07532	58	1632.56335	59	1616.203
60	1600.0	62	1568.08569	63	1552.38367	64	1536.85693
65	1521.50867	67	1491.36047	68	1476.56555	69	1461.95972
70	1447.54468	72	1419.29272	73	1405.45801	74	1391.81848
75	1378.37476	77	1352.07532	78	1339.2196	79	1326.55969
80	1314.09509	82	1289.74927	83	1277.86633	84	1266.17566
85	1254.67615	87	1232.24536	88	1221.31152	89	1210.5636
90	1200.0	92	1179.41943	93	1169.39917	94	1159.55664
95	1149.89014	97	1131.07812	98	1121.92871	99	1112.94824
100	1104.13452	102	1086.99988	103	1078.67542	104	1070.51013
105	1062.50208	107	1046.95056	108	1039.40332	109	1032.00586
110	1024.75635	112	1010.69373	113	1003.87701	114	997.200928
115	990.663635	117	977.99884	118	971.867859	119	965.868652
120	960.0	122	948.646851	123	943.159302	124	937.795593
125	932.554382	127	922.432922	128	917.549988	129	912.783325
130	908.131958	132	899.169128	133	894.855103	134	890.650879
135	886.555359	137	878.685181	138	874.908264	139	871.235168
140	867.664978	142	860.828796	143	857.560791	144	854.391357
145	851.319824	147	845.466125	148	842.682373	149	839.992859
150	837.396606	152	832.481384	153	830.160706	154	827.930481
155	825.790039	157	821.775696	158	819.900696	159	818.112915
160	816.411865	162	813.268066	163	811.82428	164	810.465332
165	809.190796	167	806.893555	168	805.870117	169	804.929626
170	804.071899	172	802.603638	173	801.992676	174	801.463501
175	801.015991	177	800.365601	178	800.162476	179	800.040649
180	800.0	182	800.162476	183	800.365601	184	800.650085
185	801.015991	187	801.992676	188	802.603638	189	803.296631
190	804.071899	192	805.870117	193	806.893555	194	808.000366
195	809.190857	197	811.824341	198	813.268066	199	814.797119
200	816.411926	202	819.900696	203	821.775757	204	823.738647
205	825.790039	207	830.160706	208	832.481384	209	834.893066
210	837.396667	212	842.682373	213	845.466125	214	848.345032
215	851.319885	217	857.560791	218	860.828796	219	864.196594
220	867.664978	222	874.908264	223	878.685181	224	882.5672

225	886.555359	227	894.855164	228	899.169189	229	903.594482
230	908.13208	232	917.549866	233	922.432922	234	927.434082
235	932.554382	237	943.159485	238	948.647034	239	954.259827
240	960.0	242	971.867798	243	977.999023	244	984.263672
245	990.663757	247	1003.87689	248	1010.69385	249	1017.65302
250	1024.75635	252	1039.40344	253	1046.95044	254	1054.64966
255	1062.50208	257	1078.67554	258	1087.00012	259	1095.48584
260	1104.13452	262	1121.92871	263	1131.07825	264	1140.39795
265	1149.89014	267	1169.39905	268	1179.41956	269	1189.61926
270	1200.0	272	1221.31177	273	1232.24548	274	1243.36646
275	1254.67603	277	1277.86658	278	1289.74927	279	1301.8252
280	1314.09546	282	1339.21997	283	1352.07556	284	1365.12708
285	1378.37512	287	1405.45837	288	1419.29297	289	1433.32202
290	1447.54468	292	1476.5658	293	1491.3606	294	1506.34277
295	1521.50854	297	1552.38391	298	1568.08594	299	1583.95935
300	1600.00037	302	1632.56348	303	1649.07556	304	1665.73303
305	1682.53003	307	1716.51135	308	1733.68005	309	1750.95618
310	1768.3302	312	1803.33276	313	1820.9386	314	1838.59973
315	1856.30151	317	1891.78027	318	1909.52795	319	1927.26172
320	1944.96497	322	1980.2157	323	1997.72839	324	2015.14197
325	2032.43811	327	2066.59717	328	2083.42041	329	2100.04492
330	2116.44995	332	2148.51172	333	2164.12451	334	2179.4292
335	2194.40186	337	2223.26196	338	2237.10327	339	2250.52173
340	2263.49438	342	2288.01636	343	2299.52197	344	2310.49512
345	2320.91699	347	2340.02515	348	2348.67603	349	2356.70093
350	2364.08423	352	2376.86865	353	2382.24292	354	2386.92407
355	2390.90161	357	2396.71558	358	2398.53882	359	2399.63452

- $\epsilon = \mathbf{0.5}$

```
cat table3.dat
```

θ	r	θ	r	θ	r	θ	r
0	1600.0	2	1599.67517	3	1599.26941	4	1598.7019
5	1597.97314	7	1596.03442	8	1594.82642	9	1593.46057
10	1591.93823	12	1588.42957	13	1586.44641	14	1584.31299
15	1582.03113	17	1577.0304	18	1574.3158	19	1571.46143
20	1568.46985	22	1562.08496	23	1558.69702	24	1555.18237
25	1551.54407	27	1543.90796	28	1539.91626	29	1535.81311
30	1531.60144	32	1522.86597	33	1518.34851	34	1513.73608

35	1509.03149	37	1499.3606	38	1494.401	39	1489.36304
40	1484.25037	42	1473.81433	43	1468.4978	44	1463.12012
45	1457.68469	47	1446.65381	48	1441.06519	49	1435.43201
50	1429.75769	52	1418.29785	53	1412.51868	54	1406.71094
55	1400.87756	57	1389.14575	58	1383.25305	59	1377.34644
60	1371.42859	62	1359.56982	63	1353.63428	64	1347.698
65	1341.76343	67	1329.90918	68	1323.99426	69	1318.09033
70	1312.19958	72	1300.46655	73	1294.62817	74	1288.81116
75	1283.01721	77	1271.50671	78	1265.79333	79	1260.11011
80	1254.45862	82	1243.25696	83	1237.70972	84	1232.19995
85	1226.72913	87	1215.90881	88	1210.56201	89	1205.25867
90	1200.0	92	1189.62073	93	1184.50208	94	1179.43176
95	1174.41077	97	1164.52014	98	1159.65198	99	1154.83594
100	1150.07288	102	1140.70825	103	1136.10779	104	1131.5625
105	1127.073	107	1118.26294	108	1113.94312	109	1109.68079
110	1105.4762	112	1097.24158	113	1093.21191	114	1089.24133
115	1085.32996	117	1077.6853	118	1073.95251	119	1070.27954
120	1066.66663	122	1059.62158	123	1056.18945	124	1052.81787
125	1049.50684	127	1043.06665	128	1039.93762	129	1036.86926
130	1033.86169	132	1028.02856	133	1025.20325	134	1022.43866
135	1019.73474	137	1014.50879	138	1011.98676	139	1009.52533
140	1007.12445	142	1002.50403	143	1000.28436	144	998.124939
145	996.025879	147	992.007996	148	990.089172	149	988.230347
150	986.431335	152	983.012817	153	981.393127	154	979.832947
155	978.332458	157	975.509644	158	974.187256	159	972.924255
160	971.720398	162	969.490051	163	968.463501	164	967.49585
165	966.587158	167	964.946289	168	964.214111	169	963.540527
170	962.925781	172	961.872131	173	961.433289	174	961.052917
175	960.73114	177	960.263184	178	960.117004	179	960.029236
180	960.0	182	960.117004	183	960.263184	184	960.467896
185	960.73114	187	961.433289	188	961.872131	189	962.369751
190	962.925781	192	964.214111	193	964.946289	194	965.737244
195	966.587158	197	968.463501	198	969.490051	199	970.575684
200	971.720398	202	974.187378	203	975.509705	204	976.891418
205	978.332458	207	981.393127	208	983.012817	209	984.692261
210	986.431335	212	990.089172	213	992.007996	214	993.986877
215	996.025879	217	1000.28436	218	1002.50403	219	1004.78406
220	1007.12445	222	1011.98688	223	1014.50879	224	1017.09149
225	1019.73474	227	1025.20325	228	1028.02869	229	1030.91479
230	1033.86169	232	1039.93762	233	1043.06665	234	1046.25647

235	1049.50684	237	1056.18958	238	1059.62158	239	1063.11389
240	1066.66663	242	1073.95251	243	1077.68542	244	1081.47778
245	1085.32996	247	1093.21191	248	1097.2417	249	1101.32971
250	1105.4762	252	1113.94324	253	1118.26294	254	1122.63965
255	1127.073	257	1136.10791	258	1140.70837	259	1145.36365
260	1150.07288	262	1159.65198	263	1164.52026	264	1169.44006
265	1174.41077	267	1184.50195	268	1189.62073	269	1194.78711
270	1200.0	272	1210.56201	273	1215.90906	274	1221.29834
275	1226.72913	277	1237.70984	278	1243.25708	279	1248.84045
280	1254.45874	282	1265.79346	283	1271.50671	284	1277.24866
285	1283.01746	287	1294.6283	288	1300.46667	289	1306.32446
290	1312.19958	292	1323.99438	293	1329.9093	294	1335.83325
295	1341.76343	297	1353.6344	298	1359.56995	299	1365.5022
300	1371.42871	302	1383.25317	303	1389.14575	304	1395.02148
305	1400.87769	307	1412.5188	308	1418.29785	309	1424.04517
310	1429.75757	312	1441.06531	313	1446.65381	314	1452.19495
315	1457.68457	317	1468.4978	318	1473.81445	319	1479.06641
320	1484.25049	322	1494.401	323	1499.3606	324	1504.23865
325	1509.03174	327	1518.34863	328	1522.86597	329	1527.28455
330	1531.60144	332	1539.91638	333	1543.90796	334	1547.78503
335	1551.54419	337	1558.69714	338	1562.08508	339	1565.34363
340	1568.46985	342	1574.3158	343	1577.0304	344	1579.60303
345	1582.03125	347	1586.44641	348	1588.42969	349	1590.26086
350	1591.93823	352	1594.82654	353	1596.03442	354	1597.08362
355	1597.97302	357	1599.26941	358	1599.67517	359	1599.9187

6 Problem 3

6.1 Question

Problem 3: Current through a Diode

The current flowing through the semiconductor diode shown is given by the equation

$$i_D = i_0(e^{\frac{qV_D}{kT}} - 1)$$

where
V_D = the voltage across the diode, in volts
i_D = the current flow through the diode, in amperes
i_0 = the leakage current of the diode, in amperes
q = the charge on an electron, 1.602×10^{-19} C
k = Boltzmann's constant, 1.38×10^{-23} J/K
T = temperature, in kelvins (K)
The leakage current i_0 of the diode is 2.0 μA. Write a computer program to calculate the current flowing through this diode for all voltages from −1.0 V to + 0.6 V, in 0.1 V steps. Repeat this process for the following temperatures: 75 °F , 100 °F, and 125 °F. Convert the temperatures from °F to kelvins.

6.2 Solution

6.2.1 Source Code

```
program P3

    implicit none
    real :: I0
    real, dimension(3) :: Tf, Tk, Tc
    real, dimension(3,17) :: Id
    real, parameter :: k=1.38e-23, q=1.602e-19, e=2.71828
    integer :: i, j, l
    real, dimension(17) :: Vd

    open(unit=999, status="old", file="input.dat")
    read(999, *) I0, Tf(1), Tf(2), Tf(3)
    close(999)

    do i=1,3
    Tc(i) = (Tf(i) - 32)/1.8
    Tk(i) = Tc(i) + 273.15
    end do
```

```
    do i=1, 17
    Vd(i) = (i - 11)/(10.0)
    end do

    open(unit=998, status="old", file="output.dat")

    do j=1,3
    do l=1,17
    Id(j,l)=(I0)*((e**((q*Vd(l))/(k*Tk(j))))-1)
    end do
    end do

    open(unit=998, status="old", file="output.dat")
    write(998, *) "Voltage ", "75\deg ", "100\deg ", "125\deg "
    do i=1, 17
    write(998, "(1f5.2, 3f25.17)") Vd(i), Id(1:3,i)
    end do

end program P3
```

6.2.2 Input File

```
cat input.dat
```

```
2.0e-6
75
100
125
```

6.2.3 Output File

```
cat output.dat
```

Voltage	75°	100°	125°
-1.0	-1.99999999495e-06	-1.99999999495e-06	-1.99999999495e-06
-0.9	-1.99999999495e-06	-1.99999999495e-06	-1.99999999495e-06
-0.8	-1.99999999495e-06	-1.99999999495e-06	-1.99999999495e-06
-0.7	-1.99999999495e-06	-1.99999999495e-06	-1.99999999495e-06
-0.6	-1.99999999495e-06	-1.99999999495e-06	-1.99999999495e-06
-0.5	-1.99999999495e-06	-1.99999999495e-06	-1.99999999495e-06
-0.4	-1.9999995402e-06	-1.99999931283e-06	-1.99999885808e-06
-0.3	-1.99998385142e-06	-1.99997271011e-06	-1.99995588446e-06
-0.2	-1.9991937279e-06	-1.99885698748e-06	-1.99842679649e-06
-0.1	-1.95984443963e-06	-1.95218512999e-06	-1.94390872821e-06
0.0	0.0	0.0	0.0
0.1	9.761224646354e-05	8.165586768882e-05	6.931222742423e-05
0.2	0.00495929922908545	0.0034971518907696	0.00254071643576026
0.3	0.24710138142108917	0.14636050164699554	0.09066145122051239
0.4	12.307244300842285	6.122029781341553	3.2327020168304443
0.5	612.9766235351562	256.0722961425781	115.26556396484375
0.6	30530.041015625	10710.990234375	4109.9306640625

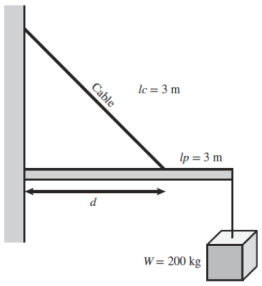
7 Problem 4

7.1 Question

Problem 4: Tension on a Cable

A 200 kilogram object is to be hung from the end of a rigid 3-m horizontal pole of negligible weight, as shown in the Figure. The pole is attached to a wall by a pivot and is supported by a 3-m cable that is attached to the wall at a higher point. The tension on this cable is given by the equation

$$T = \frac{W \cdot lc \cdot lp}{d\sqrt{lp^2 - d^2}}$$



where T is the tension on the cable, W is the weight of the object, lc is the length of the cable, lp is the length of the pole, and d is the distance along the pole at which the cable is attached.

Write a program to determine the distance d at which to attach the cable to the pole in order to minimize the tension on the cable. To do this, the program should calculate the tension on the cable at 0.1 m intervals from d = 0.5 m to d = 2.8 m, and should locate the position d that produces the minimum tension.

7.2 Solution

7.2.1 Source Code

```
program P4

    implicit none
    real :: W, Lc, Lp, Tmin, dmin
    real, dimension(24) :: d, T
    integer :: i

    open(unit=999, status="old", file="input.dat")
    read(999, *) W, Lc, Lp
    close(999)

    do i=1,24
    d(i) = (i + 4)/10.0
    T(i) = ((W*Lc*Lp)/(d(i)*sqrt((Lp**2)-((d(i))**2))))
    end do

    Tmin = minval(T)
    do i=1,24
    if (T(i) == Tmin) then
    dmin = d(i)
    exit
    end if
    end do

    open(unit=998, status="old", file="output.dat")
    write(998, *) "Distance(d)(m) ", "Tension(T)(N)"
    do i=1,24
    write(998, "(1f5.2, 1f18.6)") d(i), T(i)
    end do

    write(*, "(a, 1f5.2)") "Mnimum tension occours at d = ",
↪   dmin

end program P4
```

```
Mnimum tension occours at d =  2.10
```

7.2.2 Input File

`cat input.dat`

```
200
3
3
```

7.2.3 Output File

`cat output.dat`

Distance(d)(m)	Tension(T)(N)
0.5	1217.022095
0.6	1020.620605
0.7	881.474304
0.8	778.178772
0.9	698.856628
1.0	636.396118
1.1	586.288147
1.2	545.544739
1.3	512.118469
1.4	484.571808
1.5	461.880219
1.6	443.312103
1.7	428.354156
1.8	416.666656
1.9	408.060486
2.0	402.492218
2.1	400.080048
2.2	401.146637
2.3	406.310181
2.4	416.666656
2.5	434.176331
2.6	462.567474
2.7	509.812775
2.8	596.877808

8 Problem 5

8.1 Question

Problem 5: Geometric Mean

The geometric mean of a set of numbers x1 through xn is defined as the nth root of the product of the numbers:
geometric mean = $\sqrt[n]{x_1 x_2 x_3 \ldots . x_n}$
Write a Fortran program that will accept an arbitrary number of positive input values and calculate both the arithmetic mean (i.e., the average) and the geometric mean of the numbers.
Use a while loop to get the input values, and terminate the inputs a user enters a negative number.
Test your program by calculating the average and geometric mean of the four numbers 10, 5, 4, and 5.

8.2 Solution

8.2.1 Source Code

```
program P5

    implicit none
    integer :: i=1, p
    integer :: n
    real :: GM, AM
    real, dimension(:), allocatable :: x


    open(unit=999, status="old", file="input.dat")
    read(999, *) n
    allocate(x(1:n))
    read(999, *) x
    close(999)

    p=0
    do i=1,n
    if (x(i) < 0) then
    p=1
    exit
    end if
```

```
    end do

    AM = (sum(x))/n

    open(unit=997, status="old", file="output.dat")
    if (p == 1) then
    write(997, *) "You have entered a -ve value"
    write(997, *) "Cannot Calculate GM"
    else
    GM = (product(x))**(1/real(n))
    write(997, *) "GM = ", GM
    end if
    write(997, *) "AM =", AM

end program P5
```

8.2.2 Input File

```
cat input.dat
```

```
4
10
5
4
5
```

8.2.3 Output File

```
cat output.dat
```

```
GM  =  5.62341309
AM  =  6.0
```

9 Problem 6

9.1 Question

Problem:6

Antenna Gain Pattern The gain *G* of a certain microwave dish antenna can be expressed
as a function of angle by the equation

$$G(\theta) = |sinc\ 6\theta| \qquad \text{for } -\frac{\pi}{2} \le \theta \le \frac{\pi}{2}$$

where θ is measured in radians from the boresite of the dish, and the sinc function is defined as follows:

$$sinc\ x = \begin{cases} \frac{\sin x}{x} & x \neq 0 \\ 0 & x = 0 \end{cases}$$

Calculate a table of gain versus the angle off boresite *in degrees* for this antenna for the range $0° \le \theta \le 90°$ in 1° steps.
Label this table with the title "Antenna Gain vs Angle (deg)", and include column headings on the output.

9.2 Solution

9.2.1 Source Code

```
program P4

    implicit none
    real, dimension(91) :: G, sinc, thetar
    integer, dimension(91) :: thetad
    integer :: i
    real, parameter :: pi = 4*atan(real(1))

    do i=1,91
    thetad(i) = i-1
    thetar(i) = ((real(thetad(i)))*pi)/real(180)
    if (thetad(i) == 0) then
    G(i) = 0
    else
    G(i) = abs((sin(real((real(6))*(thetar(i)))))/real((real(6
↪   ))*(thetar(i))))
    end if
    end do

    open(unit=998, status="old", file="output.dat")
```

```
    write(998, *) "Angle(\deg) ","Antena-Gain ", "Angle(\deg)
    ↪  ","Antena-Gain " , "Angle(\deg) ","Antena-Gain"
    do i=1,91,3
    write(998, "(i3, 1x, f9.4, i3, 1x, f9.4, i3, 1x, f9.4)")
    ↪  thetad(i), G(i), thetad(i+1), G(i+1), thetad(i+2),
    ↪  G(i+2)
    end do

end program P4
```

9.2.2 Output File

- Antenna Gain vs Angle(°)

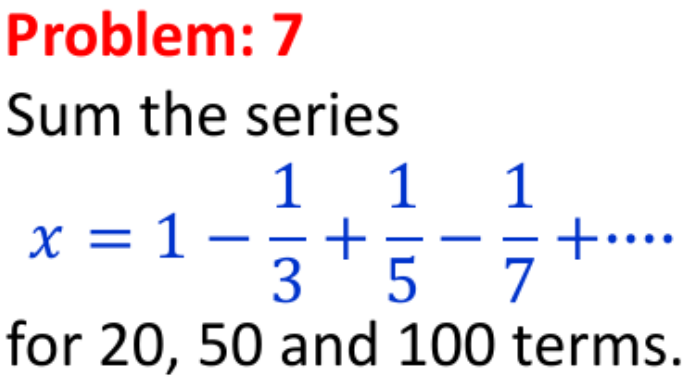
```
cat output.dat
```

Angle(°)	Antena-Gain	Angle(°)	Antena-Gain	Angle(°)	Antena-Gain
0	0.0	1	0.9982	2	0.9927
3	0.9836	4	0.971	5	0.9549
6	0.9355	7	0.9128	8	0.8871
9	0.8584	10	0.827	11	0.7931
12	0.7568	13	0.7185	14	0.6784
15	0.6366	16	0.5936	17	0.5494
18	0.5046	19	0.4591	20	0.4135
21	0.3679	22	0.3226	23	0.2778
24	0.2339	25	0.191	26	0.1494
27	0.1093	28	0.0709	29	0.0344
30	0.0	31	0.0322	32	0.062
33	0.0894	34	0.1142	35	0.1364
36	0.1559	37	0.1727	38	0.1868
39	0.1981	40	0.2067	41	0.2128
42	0.2162	43	0.2172	44	0.2158
45	0.2122	46	0.2065	47	0.1987
48	0.1892	49	0.178	50	0.1654
51	0.1515	52	0.1365	53	0.1206
54	0.1039	55	0.0868	56	0.0694
57	0.0518	58	0.0342	59	0.0169
60	0.0	61	0.0164	62	0.032
63	0.0468	64	0.0607	65	0.0735
66	0.085	67	0.0954	68	0.1044

69	0.112	70	0.1181	71	0.1229
72	0.1261	73	0.128	74	0.1283
75	0.1273	76	0.125	77	0.1213
78	0.1164	79	0.1104	80	0.1034
81	0.0954	82	0.0865	83	0.077
84	0.0668	85	0.0562	86	0.0452
87	0.0339	88	0.0226	89	0.0112
90	0.0000***	0.0	0	0.0	

10 Problem 7

10.1 Question



10.2 Solution

10.2.1 Source Code

```
program P7

    implicit none
    real, dimension(3) :: x, k
    integer :: i, j
    integer, dimension(3) :: n

    open(unit=999, status="old", file="input.dat")
```

```
    read(999, *) n
    close(999)

    do i=1,3
    x(i) = 0
    do j=1,n(i)
    k(i) = ((-1)**(real(j)+1))/((2*real(j))-1)
    x(i) = x(i) + k(i)
    end do
    end do

    open(unit=998, status="old", file="output.dat")
    do i=1,3
    write(998, "(1i4, 1a14, 1f25.16)") n(i),  " terms of x =
    ↪  ", x(i)
    end do

end program P7
```

10.2.2 Input File

```
cat input.dat
```

```
20
50
100
```

10.2.3 Output File

```
cat output.dat
```

```
 20 terms of x = 0.7729059457778931
 50 terms of x = 0.7803985476493835
100 terms of x = 0.7828981280326843
```

11 Problem 8

11.1 Question

Problem 8:
Write a program that can read two matrices of arbitrary size from two input disk files, and multiply them if they are of compatible sizes. If they are of incompatible sizes, an appropriate error message should be printed. The number of rows and columns in each matrix will be specified by two integers on the first line in each file, and the elements in each row of the matrix will be found on a single line of the input file.
Take example of the matrices A and B below.

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

$$B = \begin{bmatrix} 1. & -2. & -1. \\ 2. & 3. & 4. \\ 0. & -1. & 2. \\ 0. & -3. & 1. \end{bmatrix}$$

11.2 Solution

11.2.1 Source Code

```
program P8

    implicit none
    real, dimension(:,:), allocatable :: A, B, C
    integer :: Ai, Aj, Bi, Bj, i

    open(unit=998, status="old", file="input.dat")
    read(998, *) Ai, Aj
    read(998, *) Bi, Bj
    close(998)

    print *, "Order of *A* = ", Ai, Aj
    print *, "Order of *B* = ", Bi, Bj

    if(Aj == Bi) then
    allocate(A(1:Ai,1:Aj))
```

```
    allocate(B(1:Bi,1:Bj))
    allocate(C(1:Ai,1:Bj))

    open(unit=997, status="old", file="A.dat")
    do i=1,Ai
    read(997, *) A(i,:)
    end do
    close(997)
    open(unit=996, status="old", file="B.dat")
    do i=1, Bi
    read(996, *) B(i,:)
    end do
    close(996)

    C = matmul(A, B)

    open(unit=995, status="old", file="output.dat")
    do i=1,Ai
    write(995, *) C(i,1:Bj)
    end do

    else
    write(995, *) "The Orders of Matrices are not in order for
↪   Matrix Multiplication"
    end if

    deallocate(A)
    deallocate(B)
    deallocate(C)

end program P8
```

$$\begin{array}{llllll} \text{Order} & \text{of} & \mathbf{A} & = & 2 & 4 \\ \text{Order} & \text{of} & \mathbf{B} & = & 4 & 3 \end{array}$$

11.2.2 Input File

```
cat input.dat
```

$$\begin{array}{cc} 2 & 4 \\ 4 & 3 \end{array}$$

cat A.dat

$$\begin{bmatrix} 1.0 & -5.0 & 4.0 & 2.0 \\ -6.0 & -4.0 & 2.0 & 2.0 \end{bmatrix}$$

cat B.dat

$$\begin{bmatrix} 1.0 & -2.0 & -1.0 \\ 2.0 & 3.0 & 4.0 \\ 0.0 & -1.0 & 2.0 \\ 0.0 & -3.0 & 1.0 \end{bmatrix}$$

11.2.3 Output File

cat output.dat

$$\begin{bmatrix} -9.0 & -27.0 & -11.0 \\ -14.0 & -8.0 & -4.0 \end{bmatrix}$$

12 Problem 9

12.1 Question

Problem 9

Write a program to compute and print the values of the safe loading S for different R=25, 50, 75, ……..250 using following criteria.

$S = 17000 - 0.485\ R^2$ for R < 120

$S = 18000/ (1 + R2 /1800)$ for R = or >120

12.2 Solution

12.2.1 Source Code

```
program P9

    implicit none
    real, dimension(9) :: S
    integer :: i, j
    integer, dimension(9) :: R

    do i=1,9
```

```
    R(i) = 25*(1 + i)
    if (R(i) < 120) then
    S(i) = 17000.0 - 0.485*((real(R(i)))**2)
    else
    S(i) = 18000.0/(1.0 + (((real(R(i)))**2)/18000))
    end if
    end do

    open(unit=998, status="old", file="output.dat")
    write(998, *) "Radius-of-Curvature ", "Safe-Loading"
    do i=1,9
    write(998, *) R(i), S(i)
    end do

end program P9
```

12.2.2 Output File

```
cat output.dat
```

Radius-of-Curvature	Safe-Loading
50	15787.5
75	14271.875
100	12150.0
125	9635.6875
150	8000.0
175	6663.23926
200	5586.20654
225	4721.31152
250	4024.84473

13 Problem 10

13.1 Question

Problem 10

The wavelengths in Angstrom of the hydrogen spectrum are given by the following formula

$$\text{Wavelength} = 911.8 / (1/n^2 - 1/m^2)$$

Write a program to produce a table of values of wavelengths for all combinations of

$$m = 2, 3, 4, 5, \ldots\ldots\ldots, 50$$
$$\text{and} \quad n = 1, 2, 3, 4, 5, \ldots\ldots\ldots, (m-1)$$

The program should compute and print the wavelengths for all the desired combinations of n and m

13.2 Solution

13.2.1 Source Code

```
program P10

    implicit none
    real, dimension(50,50) :: lambda
    integer :: i, j

    do i=1,49
    do j=i+1,50
    lambda(i, j) = 911.8/((1.0/((i**2.0)))-(1.0/((j**2.0))))
    end do
    end do

    open(unit=997, status="old", file="output.dat")
    do i=1,49
    write(997, "(a, 1i3)") "**** \lambda corresponding to
    ↪  transition of \ch{e-} to n = ", i
    do j=i+1,50
    write(997,"(a, 1i3, a, 1f14.4, a)") "- From n = ", j, " is
    ↪  \lambda = ", lambda(i,j), " \AA"
    end do
    end do
```

```
end program P10
```

13.2.2 Output File

```
cat output.dat
```

1. λ corresponding to transition of e^- to n = 1
    - From n = 2 is λ = 1215.7333 Å
    - From n = 3 is λ = 1025.7750 Å
    - From n = 4 is λ = 972.5867 Å
    - From n = 5 is λ = 949.7917 Å
    - From n = 6 is λ = 937.8514 Å
    - From n = 7 is λ = 930.7958 Å
    - From n = 8 is λ = 926.2730 Å
    - From n = 9 is λ = 923.1975 Å
    - From n = 10 is λ = 921.0101 Å
    - From n = 11 is λ = 919.3983 Å
    - From n = 12 is λ = 918.1762 Å
    - From n = 13 is λ = 917.2274 Å
    - From n = 14 is λ = 916.4759 Å
    - From n = 15 is λ = 915.8705 Å
    - From n = 16 is λ = 915.3757 Å
    - From n = 17 is λ = 914.9660 Å
    - From n = 18 is λ = 914.6229 Å
    - From n = 19 is λ = 914.3328 Å
    - From n = 20 is λ = 914.0852 Å
    - From n = 21 is λ = 913.8723 Å
    - From n = 22 is λ = 913.6878 Å
    - From n = 23 is λ = 913.5269 Å
    - From n = 24 is λ = 913.3857 Å
    - From n = 25 is λ = 913.2612 Å
    - From n = 26 is λ = 913.1508 Å

- From n = 27 is $\lambda = 913.0524$ Å
- From n = 28 is $\lambda = 912.9645$ Å
- From n = 29 is $\lambda = 912.8854$ Å
- From n = 30 is $\lambda = 912.8142$ Å
- From n = 31 is $\lambda = 912.7498$ Å
- From n = 32 is $\lambda = 912.6913$ Å
- From n = 33 is $\lambda = 912.6381$ Å
- From n = 34 is $\lambda = 912.5894$ Å
- From n = 35 is $\lambda = 912.5449$ Å
- From n = 36 is $\lambda = 912.5041$ Å
- From n = 37 is $\lambda = 912.4665$ Å
- From n = 38 is $\lambda = 912.4319$ Å
- From n = 39 is $\lambda = 912.3998$ Å
- From n = 40 is $\lambda = 912.3702$ Å
- From n = 41 is $\lambda = 912.3427$ Å
- From n = 42 is $\lambda = 912.3172$ Å
- From n = 43 is $\lambda = 912.2934$ Å
- From n = 44 is $\lambda = 912.2712$ Å
- From n = 45 is $\lambda = 912.2505$ Å
- From n = 46 is $\lambda = 912.2311$ Å
- From n = 47 is $\lambda = 912.2130$ Å
- From n = 48 is $\lambda = 912.1959$ Å
- From n = 49 is $\lambda = 912.1799$ Å
- From n = 50 is $\lambda = 912.1649$ Å

2. λ corresponding to transition of e^- to n = 2

- From n = 3 is $\lambda = 6564.9595$ Å
- From n = 4 is $\lambda = 4862.9331$ Å
- From n = 5 is $\lambda = 4341.9043$ Å
- From n = 6 is $\lambda = 4103.1001$ Å
- From n = 7 is $\lambda = 3971.3955$ Å
- From n = 8 is $\lambda = 3890.3467$ Å

- From n = 9 is $\lambda = 3836.6648$ Å
- From n = 10 is $\lambda = 3799.1667$ Å
- From n = 11 is $\lambda = 3771.8906$ Å
- From n = 12 is $\lambda = 3751.4058$ Å
- From n = 13 is $\lambda = 3735.6169$ Å
- From n = 14 is $\lambda = 3723.1833$ Å
- From n = 15 is $\lambda = 3713.2126$ Å
- From n = 16 is $\lambda = 3705.0920$ Å
- From n = 17 is $\lambda = 3698.3889$ Å
- From n = 18 is $\lambda = 3692.7900$ Å
- From n = 19 is $\lambda = 3688.0649$ Å
- From n = 20 is $\lambda = 3684.0403$ Å
- From n = 21 is $\lambda = 3680.5840$ Å
- From n = 22 is $\lambda = 3677.5933$ Å
- From n = 23 is $\lambda = 3674.9883$ Å
- From n = 24 is $\lambda = 3672.7048$ Å
- From n = 25 is $\lambda = 3670.6924$ Å
- From n = 26 is $\lambda = 3668.9094$ Å
- From n = 27 is $\lambda = 3667.3225$ Å
- From n = 28 is $\lambda = 3665.9036$ Å
- From n = 29 is $\lambda = 3664.6299$ Å
- From n = 30 is $\lambda = 3663.4819$ Å
- From n = 31 is $\lambda = 3662.4441$ Å
- From n = 32 is $\lambda = 3661.5027$ Å
- From n = 33 is $\lambda = 3660.6458$ Å
- From n = 34 is $\lambda = 3659.8640$ Å
- From n = 35 is $\lambda = 3659.1482$ Å
- From n = 36 is $\lambda = 3658.4917$ Å
- From n = 37 is $\lambda = 3657.8877$ Å
- From n = 38 is $\lambda = 3657.3311$ Å
- From n = 39 is $\lambda = 3656.8169$ Å

- From n = 40 is λ = 3656.3408 Å
- From n = 41 is λ = 3655.8994 Å
- From n = 42 is λ = 3655.4890 Å
- From n = 43 is λ = 3655.1072 Å
- From n = 44 is λ = 3654.7512 Å
- From n = 45 is λ = 3654.4185 Å
- From n = 46 is λ = 3654.1074 Å
- From n = 47 is λ = 3653.8162 Å
- From n = 48 is λ = 3653.5430 Å
- From n = 49 is λ = 3653.2861 Å
- From n = 50 is λ = 3653.0449 Å

3. λ corresponding to transition of e^- to n = 3

- From n = 4 is λ = 18757.0273 Å
- From n = 5 is λ = 12822.1875 Å
- From n = 6 is λ = 10941.5996 Å
- From n = 7 is λ = 10052.5947 Å
- From n = 8 is λ = 9549.0322 Å
- From n = 9 is λ = 9231.9746 Å
- From n = 10 is λ = 9017.8018 Å
- From n = 11 is λ = 8865.6260 Å
- From n = 12 is λ = 8753.2803 Å
- From n = 13 is λ = 8667.7988 Å
- From n = 14 is λ = 8601.1504 Å
- From n = 15 is λ = 8548.1250 Å
- From n = 16 is λ = 8505.2109 Å
- From n = 17 is λ = 8469.9707 Å
- From n = 18 is λ = 8440.6621 Å
- From n = 19 is λ = 8416.0176 Å
- From n = 20 is λ = 8395.0889 Å
- From n = 21 is λ = 8377.1621 Å
- From n = 22 is λ = 8361.6855 Å

- From n = 23 is $\lambda = 8348.2305$ Å
- From n = 24 is $\lambda = 8336.4570$ Å
- From n = 25 is $\lambda = 8326.0957$ Å
- From n = 26 is $\lambda = 8316.9277$ Å
- From n = 27 is $\lambda = 8308.7773$ Å
- From n = 28 is $\lambda = 8301.4980$ Å
- From n = 29 is $\lambda = 8294.9688$ Å
- From n = 30 is $\lambda = 8289.0908$ Å
- From n = 31 is $\lambda = 8283.7793$ Å
- From n = 32 is $\lambda = 8278.9639$ Å
- From n = 33 is $\lambda = 8274.5850$ Å
- From n = 34 is $\lambda = 8270.5898$ Å
- From n = 35 is $\lambda = 8266.9365$ Å
- From n = 36 is $\lambda = 8263.5859$ Å
- From n = 37 is $\lambda = 8260.5059$ Å
- From n = 38 is $\lambda = 8257.6680$ Å
- From n = 39 is $\lambda = 8255.0459$ Å
- From n = 40 is $\lambda = 8252.6211$ Å
- From n = 41 is $\lambda = 8250.3721$ Å
- From n = 42 is $\lambda = 8248.2832$ Å
- From n = 43 is $\lambda = 8246.3389$ Å
- From n = 44 is $\lambda = 8244.5264$ Å
- From n = 45 is $\lambda = 8242.8340$ Å
- From n = 46 is $\lambda = 8241.2529$ Å
- From n = 47 is $\lambda = 8239.7705$ Å
- From n = 48 is $\lambda = 8238.3809$ Å
- From n = 49 is $\lambda = 8237.0762$ Å
- From n = 50 is $\lambda = 8235.8486$ Å

4. λ corresponding to transition of e^- to n = 4
   - From n = 5 is $\lambda = 40524.4414$ Å
   - From n = 6 is $\lambda = 26259.8379$ Å

- From n = 7 is $\lambda = 21662.1562$ Å
- From n = 8 is $\lambda = 19451.7324$ Å
- From n = 9 is $\lambda = 18179.8887$ Å
- From n = 10 is $\lambda = 17367.6172$ Å
- From n = 11 is $\lambda = 16811.8555$ Å
- From n = 12 is $\lambda = 16412.4004$ Å
- From n = 13 is $\lambda = 16114.4268$ Å
- From n = 14 is $\lambda = 15885.5820$ Å
- From n = 15 is $\lambda = 15705.6455$ Å
- From n = 16 is $\lambda = 15561.3867$ Å
- From n = 17 is $\lambda = 15443.8203$ Å
- From n = 18 is $\lambda = 15346.6592$ Å
- From n = 19 is $\lambda = 15265.3809$ Å
- From n = 20 is $\lambda = 15196.6670$ Å
- From n = 21 is $\lambda = 15138.0254$ Å
- From n = 22 is $\lambda = 15087.5625$ Å
- From n = 23 is $\lambda = 15043.8105$ Å
- From n = 24 is $\lambda = 15005.6230$ Å
- From n = 25 is $\lambda = 14972.0850$ Å
- From n = 26 is $\lambda = 14942.4678$ Å
- From n = 27 is $\lambda = 14916.1777$ Å
- From n = 28 is $\lambda = 14892.7334$ Å
- From n = 29 is $\lambda = 14871.7344$ Å
- From n = 30 is $\lambda = 14852.8506$ Å
- From n = 31 is $\lambda = 14835.8057$ Å
- From n = 32 is $\lambda = 14820.3682$ Å
- From n = 33 is $\lambda = 14806.3398$ Å
- From n = 34 is $\lambda = 14793.5557$ Å
- From n = 35 is $\lambda = 14781.8691$ Å
- From n = 36 is $\lambda = 14771.1602$ Å
- From n = 37 is $\lambda = 14761.3203$ Å

- From n = 38 is $\lambda = 14752.2598$ Å
- From n = 39 is $\lambda = 14743.8965$ Å
- From n = 40 is $\lambda = 14736.1611$ Å
- From n = 41 is $\lambda = 14728.9922$ Å
- From n = 42 is $\lambda = 14722.3359$ Å
- From n = 43 is $\lambda = 14716.1436$ Å
- From n = 44 is $\lambda = 14710.3730$ Å
- From n = 45 is $\lambda = 14704.9873$ Å
- From n = 46 is $\lambda = 14699.9531$ Å
- From n = 47 is $\lambda = 14695.2393$ Å
- From n = 48 is $\lambda = 14690.8193$ Å
- From n = 49 is $\lambda = 14686.6709$ Å
- From n = 50 is $\lambda = 14682.7695$ Å

5. λ corresponding to transition of e^- to n = 5

- From n = 6 is $\lambda = 74601.8203$ Å
- From n = 7 is $\lambda = 46539.7930$ Å
- From n = 8 is $\lambda = 37407.1797$ Å
- From n = 9 is $\lambda = 32971.3398$ Å
- From n = 10 is $\lambda = 30393.3340$ Å
- From n = 11 is $\lambda = 28731.1992$ Å
- From n = 12 is $\lambda = 27583.8652$ Å
- From n = 13 is $\lambda = 26752.4668$ Å
- From n = 14 is $\lambda = 26127.6035$ Å
- From n = 15 is $\lambda = 25644.3750$ Å
- From n = 16 is $\lambda = 25261.9922$ Å
- From n = 17 is $\lambda = 24953.6172$ Å
- From n = 18 is $\lambda = 24700.9355$ Å
- From n = 19 is $\lambda = 24491.0547$ Å
- From n = 20 is $\lambda = 24314.6680$ Å
- From n = 21 is $\lambda = 24164.8926$ Å
- From n = 22 is $\lambda = 24036.5586$ Å

- From n = 23 is $\lambda = 23925.7031$ Å
- From n = 24 is $\lambda = 23829.2559$ Å
- From n = 25 is $\lambda = 23744.7930$ Å
- From n = 26 is $\lambda = 23670.3848$ Å
- From n = 27 is $\lambda = 23604.4805$ Å
- From n = 28 is $\lambda = 23545.8242$ Å
- From n = 29 is $\lambda = 23493.3770$ Å
- From n = 30 is $\lambda = 23446.2871$ Å
- From n = 31 is $\lambda = 23403.8398$ Å
- From n = 32 is $\lambda = 23365.4453$ Å
- From n = 33 is $\lambda = 23330.5957$ Å
- From n = 34 is $\lambda = 23298.8691$ Å
- From n = 35 is $\lambda = 23269.8965$ Å
- From n = 36 is $\lambda = 23243.3672$ Å
- From n = 37 is $\lambda = 23219.0137$ Å
- From n = 38 is $\lambda = 23196.6035$ Å
- From n = 39 is $\lambda = 23175.9316$ Å
- From n = 40 is $\lambda = 23156.8262$ Å
- From n = 41 is $\lambda = 23139.1270$ Å
- From n = 42 is $\lambda = 23122.7031$ Å
- From n = 43 is $\lambda = 23107.4316$ Å
- From n = 44 is $\lambda = 23093.2090$ Å
- From n = 45 is $\lambda = 23079.9375$ Å
- From n = 46 is $\lambda = 23067.5371$ Å
- From n = 47 is $\lambda = 23055.9316$ Å
- From n = 48 is $\lambda = 23045.0547$ Å
- From n = 49 is $\lambda = 23034.8477$ Å
- From n = 50 is $\lambda = 23025.2520$ Å

6. λ corresponding to transition of e^- to n = 6
   - From n = 7 is $\lambda = 123724.2344$ Å
   - From n = 8 is $\lambda = 75028.1094$ Å

- From n = 9 is $\lambda = 59084.6406$ Å
- From n = 10 is $\lambda = 51288.7500$ Å
- From n = 11 is $\lambda = 46727.0625$ Å
- From n = 12 is $\lambda = 43766.3984$ Å
- From n = 13 is $\lambda = 41709.7070$ Å
- From n = 14 is $\lambda = 40210.3789$ Å
- From n = 15 is $\lambda = 39077.1406$ Å
- From n = 16 is $\lambda = 38196.1289$ Å
- From n = 17 is $\lambda = 37495.5234$ Å
- From n = 18 is $\lambda = 36927.8984$ Å
- From n = 19 is $\lambda = 36460.7773$ Å
- From n = 20 is $\lambda = 36071.2070$ Å
- From n = 21 is $\lambda = 35742.5586$ Å
- From n = 22 is $\lambda = 35462.5039$ Å
- From n = 23 is $\lambda = 35221.7422$ Å
- From n = 24 is $\lambda = 35013.1211$ Å
- From n = 25 is $\lambda = 34831.0664$ Å
- From n = 26 is $\lambda = 34671.1953$ Å
- From n = 27 is $\lambda = 34529.9844$ Å
- From n = 28 is $\lambda = 34404.6016$ Å
- From n = 29 is $\lambda = 34292.7422$ Å
- From n = 30 is $\lambda = 34192.5000$ Å
- From n = 31 is $\lambda = 34102.3047$ Å
- From n = 32 is $\lambda = 34020.8438$ Å
- From n = 33 is $\lambda = 33947.0156$ Å
- From n = 34 is $\lambda = 33879.8828$ Å
- From n = 35 is $\lambda = 33818.6523$ Å
- From n = 36 is $\lambda = 33762.6484$ Å
- From n = 37 is $\lambda = 33711.2891$ Å
- From n = 38 is $\lambda = 33664.0703$ Å
- From n = 39 is $\lambda = 33620.5508$ Å

- From n = 40 is $\lambda = 33580.3555$ Å
- From n = 41 is $\lambda = 33543.1523$ Å
- From n = 42 is $\lambda = 33508.6484$ Å
- From n = 43 is $\lambda = 33476.5859$ Å
- From n = 44 is $\lambda = 33446.7422$ Å
- From n = 45 is $\lambda = 33418.9141$ Å
- From n = 46 is $\lambda = 33392.9219$ Å
- From n = 47 is $\lambda = 33368.6055$ Å
- From n = 48 is $\lambda = 33345.8281$ Å
- From n = 49 is $\lambda = 33324.4570$ Å
- From n = 50 is $\lambda = 33304.3828$ Å

7. λ corresponding to transition of e^- to n = 7

- From n = 8 is $\lambda = 190627.0000$ Å
- From n = 9 is $\lambda = 113091.7031$ Å
- From n = 10 is $\lambda = 87604.3125$ Å
- From n = 11 is $\lambda = 75084.1953$ Å
- From n = 12 is $\lambda = 67722.7422$ Å
- From n = 13 is $\lambda = 62921.8008$ Å
- From n = 14 is $\lambda = 59570.9336$ Å
- From n = 15 is $\lambda = 57117.0195$ Å
- From n = 16 is $\lambda = 55254.1992$ Å
- From n = 17 is $\lambda = 53800.0000$ Å
- From n = 18 is $\lambda = 52639.0430$ Å
- From n = 19 is $\lambda = 51694.9688$ Å
- From n = 20 is $\lambda = 50915.3281$ Å
- From n = 21 is $\lambda = 50262.9727$ Å
- From n = 22 is $\lambda = 49710.9141$ Å
- From n = 23 is $\lambda = 49239.1016$ Å
- From n = 24 is $\lambda = 48832.3438$ Å
- From n = 25 is $\lambda = 48478.9492$ Å
- From n = 26 is $\lambda = 48169.8008$ Å

- From n = 27 is $\lambda = 47897.6562$ Å
- From n = 28 is $\lambda = 47656.7461$ Å
- From n = 29 is $\lambda = 47442.3828$ Å
- From n = 30 is $\lambda = 47250.7383$ Å
- From n = 31 is $\lambda = 47078.6758$ Å
- From n = 32 is $\lambda = 46923.5664$ Å
- From n = 33 is $\lambda = 46783.2305$ Å
- From n = 34 is $\lambda = 46655.8242$ Å
- From n = 35 is $\lambda = 46539.7930$ Å
- From n = 36 is $\lambda = 46433.7969$ Å
- From n = 37 is $\lambda = 46336.7109$ Å
- From n = 38 is $\lambda = 46247.5430$ Å
- From n = 39 is $\lambda = 46165.4492$ Å
- From n = 40 is $\lambda = 46089.6953$ Å
- From n = 41 is $\lambda = 46019.6406$ Å
- From n = 42 is $\lambda = 45954.7227$ Å
- From n = 43 is $\lambda = 45894.4375$ Å
- From n = 44 is $\lambda = 45838.3633$ Å
- From n = 45 is $\lambda = 45786.1094$ Å
- From n = 46 is $\lambda = 45737.3359$ Å
- From n = 47 is $\lambda = 45691.7344$ Å
- From n = 48 is $\lambda = 45649.0352$ Å
- From n = 49 is $\lambda = 45608.9961$ Å
- From n = 50 is $\lambda = 45571.3984$ Å

8. λ corresponding to transition of e^- to n = 8

- From n = 9 is $\lambda = 278045.3750$ Å
- From n = 10 is $\lambda = 162097.7656$ Å
- From n = 11 is $\lambda = 123876.8203$ Å
- From n = 12 is $\lambda = 105039.3516$ Å
- From n = 13 is $\lambda = 93924.0859$ Å
- From n = 14 is $\lambda = 86648.6250$ Å

- From n = 15 is $\lambda = 81552.2969$ Å
- From n = 16 is $\lambda = 77806.9297$ Å
- From n = 17 is $\lambda = 74954.0156$ Å
- From n = 18 is $\lambda = 72719.5547$ Å
- From n = 19 is $\lambda = 70930.0547$ Å
- From n = 20 is $\lambda = 69470.4688$ Å
- From n = 21 is $\lambda = 68261.6562$ Å
- From n = 22 is $\lambda = 67247.4219$ Å
- From n = 23 is $\lambda = 66386.8828$ Å
- From n = 24 is $\lambda = 65649.6016$ Å
- From n = 25 is $\lambda = 65012.4766$ Å
- From n = 26 is $\lambda = 64457.7070$ Å
- From n = 27 is $\lambda = 63971.3398$ Å
- From n = 28 is $\lambda = 63542.3281$ Å
- From n = 29 is $\lambda = 63161.8047$ Å
- From n = 30 is $\lambda = 62822.5820$ Å
- From n = 31 is $\lambda = 62518.7812$ Å
- From n = 32 is $\lambda = 62245.5469$ Å
- From n = 33 is $\lambda = 61998.8398$ Å
- From n = 34 is $\lambda = 61775.2812$ Å
- From n = 35 is $\lambda = 61572.0234$ Å
- From n = 36 is $\lambda = 61386.6367$ Å
- From n = 37 is $\lambda = 61217.0664$ Å
- From n = 38 is $\lambda = 61061.5234$ Å
- From n = 39 is $\lambda = 60918.5039$ Å
- From n = 40 is $\lambda = 60786.6680$ Å
- From n = 41 is $\lambda = 60664.8672$ Å
- From n = 42 is $\lambda = 60552.1016$ Å
- From n = 43 is $\lambda = 60447.4883$ Å
- From n = 44 is $\lambda = 60350.2500$ Å
- From n = 45 is $\lambda = 60259.7031$ Å

- From n = 46 is $\lambda = 60175.2422$ Å
- From n = 47 is $\lambda = 60096.3320$ Å
- From n = 48 is $\lambda = 60022.4922$ Å
- From n = 49 is $\lambda = 59953.2891$ Å
- From n = 50 is $\lambda = 59888.3398$ Å

9. λ corresponding to transition of e^- to n = 9

- From n = 10 is $\lambda = 388714.6875$ Å
- From n = 11 is $\lambda = 223413.7656$ Å
- From n = 12 is $\lambda = 168813.2500$ Å
- From n = 13 is $\lambda = 141836.7031$ Å
- From n = 14 is $\lambda = 125875.9688$ Å
- From n = 15 is $\lambda = 115399.6875$ Å
- From n = 16 is $\lambda = 108040.4844$ Å
- From n = 17 is $\lambda = 102616.9531$ Å
- From n = 18 is $\lambda = 98474.3984$ Å
- From n = 19 is $\lambda = 95221.2266$ Å
- From n = 20 is $\lambda = 92609.1484$ Å
- From n = 21 is $\lambda = 90473.3516$ Å
- From n = 22 is $\lambda = 88700.2656$ Å
- From n = 23 is $\lambda = 87209.1953$ Å
- From n = 24 is $\lambda = 85941.2891$ Å
- From n = 25 is $\lambda = 84852.7109$ Å
- From n = 26 is $\lambda = 83910.1172$ Å
- From n = 27 is $\lambda = 83087.7734$ Å
- From n = 28 is $\lambda = 82365.5000$ Å
- From n = 29 is $\lambda = 81727.2734$ Å
- From n = 30 is $\lambda = 81160.2188$ Å
- From n = 31 is $\lambda = 80653.8906$ Å
- From n = 32 is $\lambda = 80199.7188$ Å
- From n = 33 is $\lambda = 79790.6406$ Å
- From n = 34 is $\lambda = 79420.7422$ Å

- From n = 35 is $\lambda = 79085.1016$ Å
- From n = 36 is $\lambda = 78779.5156$ Å
- From n = 37 is $\lambda = 78500.4609$ Å
- From n = 38 is $\lambda = 78244.8750$ Å
- From n = 39 is $\lambda = 78010.1875$ Å
- From n = 40 is $\lambda = 77794.1250$ Å
- From n = 41 is $\lambda = 77594.7500$ Å
- From n = 42 is $\lambda = 77410.3516$ Å
- From n = 43 is $\lambda = 77239.4609$ Å
- From n = 44 is $\lambda = 77080.7734$ Å
- From n = 45 is $\lambda = 76933.1250$ Å
- From n = 46 is $\lambda = 76795.5078$ Å
- From n = 47 is $\lambda = 76667.0391$ Å
- From n = 48 is $\lambda = 76546.8984$ Å
- From n = 49 is $\lambda = 76434.3828$ Å
- From n = 50 is $\lambda = 76328.8516$ Å

10. λ corresponding to transition of e^- to n = 10

- From n = 11 is $\lambda = 525370.4375$ Å
- From n = 12 is $\lambda = 298407.2812$ Å
- From n = 13 is $\lambda = 223324.9375$ Å
- From n = 14 is $\lambda = 186159.1719$ Å
- From n = 15 is $\lambda = 164124.0000$ Å
- From n = 16 is $\lambda = 149628.7188$ Å
- From n = 17 is $\lambda = 139423.3906$ Å
- From n = 18 is $\lambda = 131885.3594$ Å
- From n = 19 is $\lambda = 126114.8672$ Å
- From n = 20 is $\lambda = 121573.3359$ Å
- From n = 21 is $\lambda = 117919.0078$ Å
- From n = 22 is $\lambda = 114924.7969$ Å
- From n = 23 is $\lambda = 112434.0859$ Å
- From n = 24 is $\lambda = 110335.4609$ Å

- From n = 25 is λ = 108547.6250 Å
- From n = 26 is λ = 107009.8672 Å
- From n = 27 is λ = 105676.0312 Å
- From n = 28 is λ = 104510.4141 Å
- From n = 29 is λ = 103484.9922 Å
- From n = 30 is λ = 102577.5000 Å
- From n = 31 is λ = 101770.0078 Å
- From n = 32 is λ = 101047.9688 Å
- From n = 33 is λ = 100399.4141 Å
- From n = 34 is λ = 99814.4688 Å
- From n = 35 is λ = 99284.8906 Å
- From n = 36 is λ = 98803.7422 Å
- From n = 37 is λ = 98365.1875 Å
- From n = 38 is λ = 97964.2188 Å
- From n = 39 is λ = 97596.6094 Å
- From n = 40 is λ = 97258.6719 Å
- From n = 41 is λ = 96947.2422 Å
- From n = 42 is λ = 96659.5703 Å
- From n = 43 is λ = 96393.2656 Å
- From n = 44 is λ = 96146.2344 Å
- From n = 45 is λ = 95916.6250 Å
- From n = 46 is λ = 95702.8125 Å
- From n = 47 is λ = 95503.3750 Å
- From n = 48 is λ = 95317.0234 Å
- From n = 49 is λ = 95142.6250 Å
- From n = 50 is λ = 94979.1719 Å

11. λ corresponding to transition of e^- to n = 11

- From n = 12 is λ = 690748.1875 Å
- From n = 13 is λ = 388445.8750 Å
- From n = 14 is λ = 288323.3438 Å
- From n = 15 is λ = 238689.9844 Å

- From n = 16 is $\lambda = 209214.2188$ Å
- From n = 17 is $\lambda = 189790.1094$ Å
- From n = 18 is $\lambda = 176089.7031$ Å
- From n = 19 is $\lambda = 165951.4062$ Å
- From n = 20 is $\lambda = 158176.0625$ Å
- From n = 21 is $\lambda = 152045.5156$ Å
- From n = 22 is $\lambda = 147103.7500$ Å
- From n = 23 is $\lambda = 143047.5781$ Å
- From n = 24 is $\lambda = 139667.7188$ Å
- From n = 25 is $\lambda = 136815.2344$ Å
- From n = 26 is $\lambda = 134381.2500$ Å
- From n = 27 is $\lambda = 132284.4844$ Å
- From n = 28 is $\lambda = 130463.0391$ Å
- From n = 29 is $\lambda = 128869.0000$ Å
- From n = 30 is $\lambda = 127464.7266$ Å
- From n = 31 is $\lambda = 126220.2578$ Å
- From n = 32 is $\lambda = 125111.4844$ Å
- From n = 33 is $\lambda = 124118.7812$ Å
- From n = 34 is $\lambda = 123226.0312$ Å
- From n = 35 is $\lambda = 122419.8906$ Å
- From n = 36 is $\lambda = 121689.2188$ Å
- From n = 37 is $\lambda = 121024.6484$ Å
- From n = 38 is $\lambda = 120418.2500$ Å
- From n = 39 is $\lambda = 119863.2734$ Å
- From n = 40 is $\lambda = 119353.9453$ Å
- From n = 41 is $\lambda = 118885.2812$ Å
- From n = 42 is $\lambda = 118452.9766$ Å
- From n = 43 is $\lambda = 118053.3047$ Å
- From n = 44 is $\lambda = 117682.9844$ Å
- From n = 45 is $\lambda = 117339.1797$ Å
- From n = 46 is $\lambda = 117019.3672$ Å

- From n = 47 is $\lambda = 116721.3203$ Å
- From n = 48 is $\lambda = 116443.0938$ Å
- From n = 49 is $\lambda = 116182.9219$ Å
- From n = 50 is $\lambda = 115939.2656$ Å

12. λ corresponding to transition of e^- to n = 12

- From n = 13 is $\lambda = 887582.6250$ Å
- From n = 14 is $\lambda = 494896.9375$ Å
- From n = 15 is $\lambda = 364720.0000$ Å
- From n = 16 is $\lambda = 300112.4375$ Å
- From n = 17 is $\lambda = 261692.8906$ Å
- From n = 18 is $\lambda = 236338.5625$ Å
- From n = 19 is $\lambda = 218428.6094$ Å
- From n = 20 is $\lambda = 205155.0000$ Å
- From n = 21 is $\lambda = 194959.4062$ Å
- From n = 22 is $\lambda = 186908.2500$ Å
- From n = 23 is $\lambda = 180408.5000$ Å
- From n = 24 is $\lambda = 175065.5938$ Å
- From n = 25 is $\lambda = 170607.0625$ Å
- From n = 26 is $\lambda = 166838.8281$ Å
- From n = 27 is $\lambda = 163619.0000$ Å
- From n = 28 is $\lambda = 160841.5156$ Å
- From n = 29 is $\lambda = 158425.5625$ Å
- From n = 30 is $\lambda = 156308.5625$ Å
- From n = 31 is $\lambda = 154441.2969$ Å
- From n = 32 is $\lambda = 152784.5156$ Å
- From n = 33 is $\lambda = 151306.7031$ Å
- From n = 34 is $\lambda = 149982.0938$ Å
- From n = 35 is $\lambda = 148789.5625$ Å
- From n = 36 is $\lambda = 147711.5938$ Å
- From n = 37 is $\lambda = 146733.5469$ Å
- From n = 38 is $\lambda = 145843.1094$ Å

- From n = 39 is $\lambda = 145029.8281$ Å
- From n = 40 is $\lambda = 144284.8281$ Å
- From n = 41 is $\lambda = 143600.4844$ Å
- From n = 42 is $\lambda = 142970.2344$ Å
- From n = 43 is $\lambda = 142388.4062$ Å
- From n = 44 is $\lambda = 141850.0156$ Å
- From n = 45 is $\lambda = 141350.8125$ Å
- From n = 46 is $\lambda = 140886.9688$ Å
- From n = 47 is $\lambda = 140455.1719$ Å
- From n = 48 is $\lambda = 140052.4844$ Å
- From n = 49 is $\lambda = 139676.2812$ Å
- From n = 50 is $\lambda = 139324.2656$ Å

13. λ corresponding to transition of e^- to n = 13

- From n = 14 is $\lambda = 1118609.5000$ Å
- From n = 15 is $\lambda = 619128.5000$ Å
- From n = 16 is $\lambda = 453426.5938$ Å
- From n = 17 is $\lambda = 371110.1875$ Å
- From n = 18 is $\lambda = 322106.5625$ Å
- From n = 19 is $\lambda = 289729.1875$ Å
- From n = 20 is $\lambda = 266829.7812$ Å
- From n = 21 is $\lambda = 249836.5469$ Å
- From n = 22 is $\lambda = 236766.9531$ Å
- From n = 23 is $\lambda = 226432.8750$ Å
- From n = 24 is $\lambda = 218079.2500$ Å
- From n = 25 is $\lambda = 211203.6719$ Å
- From n = 26 is $\lambda = 205458.9219$ Å
- From n = 27 is $\lambda = 200597.6250$ Å
- From n = 28 is $\lambda = 196438.7656$ Å
- From n = 29 is $\lambda = 192847.0469$ Å
- From n = 30 is $\lambda = 189719.2500$ Å
- From n = 31 is $\lambda = 186975.4062$ Å

- From n = 32 is $\lambda = 184552.5781$ Å
- From n = 33 is $\lambda = 182400.6406$ Å
- From n = 34 is $\lambda = 180479.1250$ Å
- From n = 35 is $\lambda = 178755.1094$ Å
- From n = 36 is $\lambda = 177201.4844$ Å
- From n = 37 is $\lambda = 175795.7969$ Å
- From n = 38 is $\lambda = 174519.2344$ Å
- From n = 39 is $\lambda = 173355.9688$ Å
- From n = 40 is $\lambda = 172292.5938$ Å
- From n = 41 is $\lambda = 171317.6875$ Å
- From n = 42 is $\lambda = 170421.4062$ Å
- From n = 43 is $\lambda = 169595.3438$ Å
- From n = 44 is $\lambda = 168832.1250$ Å
- From n = 45 is $\lambda = 168125.4062$ Å
- From n = 46 is $\lambda = 167469.6094$ Å
- From n = 47 is $\lambda = 166859.8438$ Å
- From n = 48 is $\lambda = 166291.8281$ Å
- From n = 49 is $\lambda = 165761.7188$ Å
- From n = 50 is $\lambda = 165266.1875$ Å

14. λ corresponding to transition of e^- to n = 14

- From n = 15 is $\lambda = 1386565.2500$ Å
- From n = 16 is $\lambda = 762508.0000$ Å
- From n = 17 is $\lambda = 555354.8750$ Å
- From n = 18 is $\lambda = 452366.8125$ Å
- From n = 19 is $\lambda = 391001.9375$ Å
- From n = 20 is $\lambda = 350417.2500$ Å
- From n = 21 is $\lambda = 321683.0625$ Å
- From n = 22 is $\lambda = 300336.7812$ Å
- From n = 23 is $\lambda = 283901.1250$ Å
- From n = 24 is $\lambda = 270890.9688$ Å
- From n = 25 is $\lambda = 260362.4844$ Å

- From n = 26 is $\lambda = 251687.2031$ Å
- From n = 27 is $\lambda = 244430.8438$ Å
- From n = 28 is $\lambda = 238283.7344$ Å
- From n = 29 is $\lambda = 233019.3281$ Å
- From n = 30 is $\lambda = 228468.0781$ Å
- From n = 31 is $\lambda = 224500.6719$ Å
- From n = 32 is $\lambda = 221016.7969$ Å
- From n = 33 is $\lambda = 217937.5625$ Å
- From n = 34 is $\lambda = 215200.0000$ Å
- From n = 35 is $\lambda = 212753.3438$ Å
- From n = 36 is $\lambda = 210556.1719$ Å
- From n = 37 is $\lambda = 208574.4375$ Å
- From n = 38 is $\lambda = 206779.8750$ Å
- From n = 39 is $\lambda = 205148.7969$ Å
- From n = 40 is $\lambda = 203661.3125$ Å
- From n = 41 is $\lambda = 202300.4844$ Å
- From n = 42 is $\lambda = 201051.8906$ Å
- From n = 43 is $\lambda = 199903.1875$ Å
- From n = 44 is $\lambda = 198843.6562$ Å
- From n = 45 is $\lambda = 197864.0938$ Å
- From n = 46 is $\lambda = 196956.4062$ Å
- From n = 47 is $\lambda = 196113.5469$ Å
- From n = 48 is $\lambda = 195329.3750$ Å
- From n = 49 is $\lambda = 194598.3750$ Å
- From n = 50 is $\lambda = 193915.7969$ Å

15. λ corresponding to transition of e^- to n = 15

- From n = 16 is $\lambda = 1694182.8750$ Å
- From n = 17 is $\lambda = 926403.0625$ Å
- From n = 18 is $\lambda = 671416.3125$ Å
- From n = 19 is $\lambda = 544565.7500$ Å
- From n = 20 is $\lambda = 468925.6562$ Å

- From n = 21 is $\lambda = 418858.0938$ Å
- From n = 22 is $\lambda = 383378.4062$ Å
- From n = 23 is $\lambda = 356996.6875$ Å
- From n = 24 is $\lambda = 336664.5938$ Å
- From n = 25 is $\lambda = 320554.6875$ Å
- From n = 26 is $\lambda = 307505.0312$ Å
- From n = 27 is $\lambda = 296742.0625$ Å
- From n = 28 is $\lambda = 287730.7812$ Å
- From n = 29 is $\lambda = 280089.8438$ Å
- From n = 30 is $\lambda = 273540.0000$ Å
- From n = 31 is $\lambda = 267872.2188$ Å
- From n = 32 is $\lambda = 262927.0625$ Å
- From n = 33 is $\lambda = 258580.7656$ Å
- From n = 34 is $\lambda = 254735.9531$ Å
- From n = 35 is $\lambda = 251314.8750$ Å
- From n = 36 is $\lambda = 248254.7812$ Å
- From n = 37 is $\lambda = 245504.5312$ Å
- From n = 38 is $\lambda = 243021.9844$ Å
- From n = 39 is $\lambda = 240772.1875$ Å
- From n = 40 is $\lambda = 238725.7969$ Å
- From n = 41 is $\lambda = 236858.2031$ Å
- From n = 42 is $\lambda = 235148.4219$ Å
- From n = 43 is $\lambda = 233578.5625$ Å
- From n = 44 is $\lambda = 232133.2812$ Å
- From n = 45 is $\lambda = 230799.3750$ Å
- From n = 46 is $\lambda = 229565.2969$ Å
- From n = 47 is $\lambda = 228421.0625$ Å
- From n = 48 is $\lambda = 227357.9219$ Å
- From n = 49 is $\lambda = 226368.1562$ Å
- From n = 50 is $\lambda = 225445.0312$ Å

16. λ corresponding to transition of e^- to n = 16

- From n = 17 is $\lambda = 2044200.7500$ Å
- From n = 18 is $\lambda = 1112181.5000$ Å
- From n = 19 is $\lambda = 802522.8750$ Å
- From n = 20 is $\lambda = 648391.0625$ Å
- From n = 21 is $\lambda = 556424.7500$ Å
- From n = 22 is $\lambda = 495507.2812$ Å
- From n = 23 is $\lambda = 452306.2500$ Å
- From n = 24 is $\lambda = 420157.4062$ Å
- From n = 25 is $\lambda = 395360.4375$ Å
- From n = 26 is $\lambda = 375696.3438$ Å
- From n = 27 is $\lambda = 359754.2812$ Å
- From n = 28 is $\lambda = 346594.5000$ Å
- From n = 29 is $\lambda = 335567.3125$ Å
- From n = 30 is $\lambda = 326209.1875$ Å
- From n = 31 is $\lambda = 318180.6875$ Å
- From n = 32 is $\lambda = 311227.7188$ Å
- From n = 33 is $\lambda = 305156.3438$ Å
- From n = 34 is $\lambda = 299816.0625$ Å
- From n = 35 is $\lambda = 295088.2188$ Å
- From n = 36 is $\lambda = 290878.2188$ Å
- From n = 37 is $\lambda = 287109.6875$ Å
- From n = 38 is $\lambda = 283720.2188$ Å
- From n = 39 is $\lambda = 280658.5312$ Å
- From n = 40 is $\lambda = 277881.8750$ Å
- From n = 41 is $\lambda = 275354.6250$ Å
- From n = 42 is $\lambda = 273046.6250$ Å
- From n = 43 is $\lambda = 270932.2500$ Å
- From n = 44 is $\lambda = 268989.6875$ Å
- From n = 45 is $\lambda = 267200.1875$ Å
- From n = 46 is $\lambda = 265547.5312$ Å
- From n = 47 is $\lambda = 264017.6875$ Å

- From n = 48 is $\lambda = 262598.4062$ Å
- From n = 49 is $\lambda = 261278.9375$ Å
- From n = 50 is $\lambda = 260049.9062$ Å

17. λ corresponding to transition of e^- to n = 17

- From n = 18 is $\lambda = 2439351.0000$ Å
- From n = 19 is $\lambda = 1321210.5000$ Å
- From n = 20 is $\lambda = 949586.1250$ Å
- From n = 21 is $\lambda = 764526.2500$ Å
- From n = 22 is $\lambda = 654045.7500$ Å
- From n = 23 is $\lambda = 580820.3750$ Å
- From n = 24 is $\lambda = 528856.6875$ Å
- From n = 25 is $\lambda = 490160.2812$ Å
- From n = 26 is $\lambda = 460291.6875$ Å
- From n = 27 is $\lambda = 436588.4375$ Å
- From n = 28 is $\lambda = 417357.5625$ Å
- From n = 29 is $\lambda = 401471.1562$ Å
- From n = 30 is $\lambda = 388149.2188$ Å
- From n = 31 is $\lambda = 376835.2500$ Å
- From n = 32 is $\lambda = 367121.6875$ Å
- From n = 33 is $\lambda = 358703.2188$ Å
- From n = 34 is $\lambda = 351346.9375$ Å
- From n = 35 is $\lambda = 344871.7812$ Å
- From n = 36 is $\lambda = 339135.2500$ Å
- From n = 37 is $\lambda = 334023.5625$ Å
- From n = 38 is $\lambda = 329444.7812$ Å
- From n = 39 is $\lambda = 325323.8750$ Å
- From n = 40 is $\lambda = 321599.0312$ Å
- From n = 41 is $\lambda = 318218.8438$ Å
- From n = 42 is $\lambda = 315140.3125$ Å
- From n = 43 is $\lambda = 312327.1250$ Å
- From n = 44 is $\lambda = 309748.4688$ Å

- From n = 45 is $\lambda = 307377.9375$ Å
- From n = 46 is $\lambda = 305192.9688$ Å
- From n = 47 is $\lambda = 303173.9688$ Å
- From n = 48 is $\lambda = 301303.9688$ Å
- From n = 49 is $\lambda = 299568.1562$ Å
- From n = 50 is $\lambda = 297953.6250$ Å

18. λ corresponding to transition of e^- to n = 18

- From n = 19 is $\lambda = 2882371.2500$ Å
- From n = 20 is $\lambda = 1554858.7500$ Å
- From n = 21 is $\lambda = 1113518.2500$ Å
- From n = 22 is $\lambda = 893655.0625$ Å
- From n = 23 is $\lambda = 762336.0000$ Å
- From n = 24 is $\lambda = 675253.0000$ Å
- From n = 25 is $\lambda = 613420.2500$ Å
- From n = 26 is $\lambda = 567346.8125$ Å
- From n = 27 is $\lambda = 531761.7500$ Å
- From n = 28 is $\lambda = 503503.8750$ Å
- From n = 29 is $\lambda = 480562.6875$ Å
- From n = 30 is $\lambda = 461598.7500$ Å
- From n = 31 is $\lambda = 445685.5625$ Å
- From n = 32 is $\lambda = 432161.9375$ Å
- From n = 33 is $\lambda = 420543.5938$ Å
- From n = 34 is $\lambda = 410467.8125$ Å
- From n = 35 is $\lambda = 401657.5000$ Å
- From n = 36 is $\lambda = 393897.5938$ Å
- From n = 37 is $\lambda = 387018.5312$ Å
- From n = 38 is $\lambda = 380884.9062$ Å
- From n = 39 is $\lambda = 375387.3750$ Å
- From n = 40 is $\lambda = 370436.5938$ Å
- From n = 41 is $\lambda = 365959.0000$ Å
- From n = 42 is $\lambda = 361893.4062$ Å

- From n = 43 is $\lambda = 358188.5312$ Å
- From n = 44 is $\lambda = 354801.0625$ Å
- From n = 45 is $\lambda = 351694.2812$ Å
- From n = 46 is $\lambda = 348836.7812$ Å
- From n = 47 is $\lambda = 346201.5000$ Å
- From n = 48 is $\lambda = 343765.1562$ Å
- From n = 49 is $\lambda = 341507.5000$ Å
- From n = 50 is $\lambda = 339410.8438$ Å

19. λ corresponding to transition of e^- to n = 19

- From n = 20 is $\lambda = 3375998.2500$ Å
- From n = 21 is $\lambda = 1814493.7500$ Å
- From n = 22 is $\lambda = 1295230.3750$ Å
- From n = 23 is $\lambda = 1036461.6250$ Å
- From n = 24 is $\lambda = 881842.1250$ Å
- From n = 25 is $\lambda = 779260.8750$ Å
- From n = 26 is $\lambda = 706387.4375$ Å
- From n = 27 is $\lambda = 652058.4375$ Å
- From n = 28 is $\lambda = 610073.9375$ Å
- From n = 29 is $\lambda = 576715.4375$ Å
- From n = 30 is $\lambda = 549617.5000$ Å
- From n = 31 is $\lambda = 527204.3125$ Å
- From n = 32 is $\lambda = 508385.5938$ Å
- From n = 33 is $\lambda = 492383.2812$ Å
- From n = 34 is $\lambda = 478627.3750$ Å
- From n = 35 is $\lambda = 466690.7188$ Å
- From n = 36 is $\lambda = 456247.1875$ Å
- From n = 37 is $\lambda = 447043.4375$ Å
- From n = 38 is $\lambda = 438879.7500$ Å
- From n = 39 is $\lambda = 431596.6250$ Å
- From n = 40 is $\lambda = 425065.0938$ Å
- From n = 41 is $\lambda = 419180.0000$ Å

- From n = 42 is $\lambda = 413854.5312$ Å
- From n = 43 is $\lambda = 409016.4688$ Å
- From n = 44 is $\lambda = 404605.3438$ Å
- From n = 45 is $\lambda = 400570.0938$ Å
- From n = 46 is $\lambda = 396867.3438$ Å
- From n = 47 is $\lambda = 393459.9688$ Å
- From n = 48 is $\lambda = 390316.0938$ Å
- From n = 49 is $\lambda = 387408.1562$ Å
- From n = 50 is $\lambda = 384712.2500$ Å

20. λ corresponding to transition of e^- to n = 20

- From n = 21 is $\lambda = 3922965.2500$ Å
- From n = 22 is $\lambda = 2101481.7500$ Å
- From n = 23 is $\lambda = 1495635.0000$ Å
- From n = 24 is $\lambda = 1193629.1250$ Å
- From n = 25 is $\lambda = 1013111.1250$ Å
- From n = 26 is $\lambda = 893299.7500$ Å
- From n = 27 is $\lambda = 808148.6250$ Å
- From n = 28 is $\lambda = 744636.6875$ Å
- From n = 29 is $\lambda = 695531.8125$ Å
- From n = 30 is $\lambda = 656496.0000$ Å
- From n = 31 is $\lambda = 624769.9375$ Å
- From n = 32 is $\lambda = 598514.8750$ Å
- From n = 33 is $\lambda = 576458.7500$ Å
- From n = 34 is $\lambda = 557693.5625$ Å
- From n = 35 is $\lambda = 541553.9375$ Å
- From n = 36 is $\lambda = 527541.4375$ Å
- From n = 37 is $\lambda = 515275.2500$ Å
- From n = 38 is $\lambda = 504459.4688$ Å
- From n = 39 is $\lambda = 494860.9688$ Å
- From n = 40 is $\lambda = 486293.3438$ Å
- From n = 41 is $\lambda = 478606.0312$ Å

- From n = 42 is $\lambda = 471676.0312$ Å
- From n = 43 is $\lambda = 465401.8750$ Å
- From n = 44 is $\lambda = 459699.1875$ Å
- From n = 45 is $\lambda = 454497.2500$ Å
- From n = 46 is $\lambda = 449736.3438$ Å
- From n = 47 is $\lambda = 445365.6875$ Å
- From n = 48 is $\lambda = 441341.8438$ Å
- From n = 49 is $\lambda = 437627.5312$ Å
- From n = 50 is $\lambda = 434190.5000$ Å

21. λ corresponding to transition of e^- to n = 21

- From n = 22 is $\lambda = 4526003.0000$ Å
- From n = 23 is $\lambda = 2417192.2500$ Å
- From n = 24 is $\lambda = 1715642.7500$ Å
- From n = 25 is $\lambda = 1365841.5000$ Å
- From n = 26 is $\lambda = 1156690.0000$ Å
- From n = 27 is $\lambda = 1017825.1875$ Å
- From n = 28 is $\lambda = 919094.3125$ Å
- From n = 29 is $\lambda = 845423.1875$ Å
- From n = 30 is $\lambda = 788438.8125$ Å
- From n = 31 is $\lambda = 743118.7500$ Å
- From n = 32 is $\lambda = 706268.0625$ Å
- From n = 33 is $\lambda = 675757.6875$ Å
- From n = 34 is $\lambda = 650114.6875$ Å
- From n = 35 is $\lambda = 628287.1875$ Å
- From n = 36 is $\lambda = 609504.6875$ Å
- From n = 37 is $\lambda = 593189.7500$ Å
- From n = 38 is $\lambda = 578901.1875$ Å
- From n = 39 is $\lambda = 566296.1875$ Å
- From n = 40 is $\lambda = 555104.4375$ Å
- From n = 41 is $\lambda = 545110.0000$ Å
- From n = 42 is $\lambda = 536138.3750$ Å

- From n = 43 is $\lambda = 528046.8125$ Å
- From n = 44 is $\lambda = 520717.6875$ Å
- From n = 45 is $\lambda = 514053.1250$ Å
- From n = 46 is $\lambda = 507971.1250$ Å
- From n = 47 is $\lambda = 502402.3125$ Å
- From n = 48 is $\lambda = 497287.7812$ Å
- From n = 49 is $\lambda = 492577.1562$ Å
- From n = 50 is $\lambda = 488227.0312$ Å

22. λ corresponding to transition of e^- to n = 22

- From n = 23 is $\lambda = 5187862.0000$ Å
- From n = 24 is $\lambda = 2762992.7500$ Å
- From n = 25 is $\lambda = 1956166.8750$ Å
- From n = 26 is $\lambda = 1553783.5000$ Å
- From n = 27 is $\lambda = 1313126.1250$ Å
- From n = 28 is $\lambda = 1153293.3750$ Å
- From n = 29 is $\lambda = 1039615.5000$ Å
- From n = 30 is $\lambda = 954759.9375$ Å
- From n = 31 is $\lambda = 889098.7500$ Å
- From n = 32 is $\lambda = 836856.8750$ Å
- From n = 33 is $\lambda = 794360.1875$ Å
- From n = 34 is $\lambda = 759160.4375$ Å
- From n = 35 is $\lambda = 729563.1250$ Å
- From n = 36 is $\lambda = 704358.8125$ Å
- From n = 37 is $\lambda = 682661.1250$ Å
- From n = 38 is $\lambda = 663805.6250$ Å
- From n = 39 is $\lambda = 647284.8750$ Å
- From n = 40 is $\lambda = 632704.2500$ Å
- From n = 41 is $\lambda = 619752.8125$ Å
- From n = 42 is $\lambda = 608182.0625$ Å
- From n = 43 is $\lambda = 597790.8125$ Å
- From n = 44 is $\lambda = 588415.0000$ Å

- From n = 45 is $\lambda = 579919.0000$ Å
- From n = 46 is $\lambda = 572190.3125$ Å
- From n = 47 is $\lambda = 565134.1875$ Å
- From n = 48 is $\lambda = 558670.8750$ Å
- From n = 49 is $\lambda = 552732.5000$ Å
- From n = 50 is $\lambda = 547260.9375$ Å

23. λ corresponding to transition of e^- to n = 23

- From n = 24 is $\lambda = 5911256.5000$ Å
- From n = 25 is $\lambda = 3140247.7500$ Å
- From n = 26 is $\lambda = 2218117.7500$ Å
- From n = 27 is $\lambda = 1758137.1250$ Å
- From n = 28 is $\lambda = 1482965.6250$ Å
- From n = 29 is $\lambda = 1300159.5000$ Å
- From n = 30 is $\lambda = 1170102.3750$ Å
- From n = 31 is $\lambda = 1072988.1250$ Å
- From n = 32 is $\lambda = 997814.9375$ Å
- From n = 33 is $\lambda = 937983.2500$ Å
- From n = 34 is $\lambda = 889294.4375$ Å
- From n = 35 is $\lambda = 848950.0000$ Å
- From n = 36 is $\lambda = 815013.6250$ Å
- From n = 37 is $\lambda = 786102.9375$ Å
- From n = 38 is $\lambda = 761204.5000$ Å
- From n = 39 is $\lambda = 739559.0000$ Å
- From n = 40 is $\lambda = 720585.8750$ Å
- From n = 41 is $\lambda = 703834.3125$ Å
- From n = 42 is $\lambda = 688948.6875$ Å
- From n = 43 is $\lambda = 675644.4375$ Å
- From n = 44 is $\lambda = 663691.8750$ Å
- From n = 45 is $\lambda = 652903.0000$ Å
- From n = 46 is $\lambda = 643122.9375$ Å
- From n = 47 is $\lambda = 634222.5625$ Å

- From n = 48 is $\lambda = 626093.7500$ Å
- From n = 49 is $\lambda = 618645.0625$ Å
- From n = 50 is $\lambda = 611798.8125$ Å

24. λ corresponding to transition of e^- to n = 24

- From n = 25 is $\lambda = 6698936.0000$ Å
- From n = 26 is $\lambda = 3550330.5000$ Å
- From n = 27 is $\lambda = 2502408.2500$ Å
- From n = 28 is $\lambda = 1979587.7500$ Å
- From n = 29 is $\lambda = 1666756.5000$ Å
- From n = 30 is $\lambda = 1458880.0000$ Å
- From n = 31 is $\lambda = 1310945.8750$ Å
- From n = 32 is $\lambda = 1200449.7500$ Å
- From n = 33 is $\lambda = 1114891.3750$ Å
- From n = 34 is $\lambda = 1046771.5625$ Å
- From n = 35 is $\lambda = 991319.0625$ Å
- From n = 36 is $\lambda = 945354.2500$ Å
- From n = 37 is $\lambda = 906676.3750$ Å
- From n = 38 is $\lambda = 873714.4375$ Å
- From n = 39 is $\lambda = 845316.6875$ Å
- From n = 40 is $\lambda = 820620.0000$ Å
- From n = 41 is $\lambda = 798964.5625$ Å
- From n = 42 is $\lambda = 779837.6250$ Å
- From n = 43 is $\lambda = 762834.9375$ Å
- From n = 44 is $\lambda = 747633.0000$ Å
- From n = 45 is $\lambda = 733970.6875$ Å
- From n = 46 is $\lambda = 721634.0000$ Å
- From n = 47 is $\lambda = 710446.8750$ Å
- From n = 48 is $\lambda = 700262.3750$ Å
- From n = 49 is $\lambda = 690957.5625$ Å
- From n = 50 is $\lambda = 682428.2500$ Å

25. λ corresponding to transition of e^- to n = 25

- From n = 26 is λ = 7553641.0000 Å
- From n = 27 is λ = 3994605.2500 Å
- From n = 28 is λ = 2809949.7500 Å
- From n = 29 is λ = 2218819.0000 Å
- From n = 30 is λ = 1865045.6250 Å
- From n = 31 is λ = 1629910.6250 Å
- From n = 32 is λ = 1462536.3750 Å
- From n = 33 is λ = 1337486.8750 Å
- From n = 34 is λ = 1240631.8750 Å
- From n = 35 is λ = 1163494.8750 Å
- From n = 36 is λ = 1100682.6250 Å
- From n = 37 is λ = 1048600.7500 Å
- From n = 38 is λ = 1004761.3125 Å
- From n = 39 is λ = 967388.3125 Å
- From n = 40 is λ = 935179.5000 Å
- From n = 41 is λ = 907159.0625 Å
- From n = 42 is λ = 882580.7500 Å
- From n = 43 is λ = 860865.1250 Å
- From n = 44 is λ = 841554.5000 Å
- From n = 45 is λ = 824283.5000 Å
- From n = 46 is λ = 808756.1875 Å
- From n = 47 is λ = 794731.0000 Å
- From n = 48 is λ = 782008.3125 Å
- From n = 49 is λ = 770422.2500 Å
- From n = 50 is λ = 759833.3750 Å

26. λ corresponding to transition of e^- to n = 26

- From n = 27 is λ = 8478087.0000 Å
- From n = 28 is λ = 4474438.0000 Å
- From n = 29 is λ = 3141653.5000 Å

- From n = 30 is $\lambda = 2476514.0000$ Å
- From n = 31 is $\lambda = 2078379.5000$ Å
- From n = 32 is $\lambda = 1813706.3750$ Å
- From n = 33 is $\lambda = 1625264.6250$ Å
- From n = 34 is $\lambda = 1484440.7500$ Å
- From n = 35 is $\lambda = 1375339.7500$ Å
- From n = 36 is $\lambda = 1288426.2500$ Å
- From n = 37 is $\lambda = 1217633.2500$ Å
- From n = 38 is $\lambda = 1158916.7500$ Å
- From n = 39 is $\lambda = 1109478.2500$ Å
- From n = 40 is $\lambda = 1067319.1250$ Å
- From n = 41 is $\lambda = 1030974.5000$ Å
- From n = 42 is $\lambda = 999346.1875$ Å
- From n = 43 is $\lambda = 971594.7500$ Å
- From n = 44 is $\lambda = 947067.8125$ Å
- From n = 45 is $\lambda = 925250.5625$ Å
- From n = 46 is $\lambda = 905731.5000$ Å
- From n = 47 is $\lambda = 888177.6250$ Å
- From n = 48 is $\lambda = 872317.0000$ Å
- From n = 49 is $\lambda = 857925.0625$ Å
- From n = 50 is $\lambda = 844814.6875$ Å

27. λ corresponding to transition of e^- to n = 27

- From n = 28 is $\lambda = 9475025.0000$ Å
- From n = 29 is $\lambda = 4991201.0000$ Å
- From n = 30 is $\lambda = 3498433.0000$ Å
- From n = 31 is $\lambda = 2753357.2500$ Å
- From n = 32 is $\lambda = 2307305.2500$ Å
- From n = 33 is $\lambda = 2010724.1250$ Å
- From n = 34 is $\lambda = 1799521.7500$ Å
- From n = 35 is $\lambda = 1641653.6250$ Å
- From n = 36 is $\lambda = 1519319.3750$ Å

- From n = 37 is λ = 1421839.6250 Å
- From n = 38 is λ = 1342419.5000 Å
- From n = 39 is λ = 1276530.3750 Å
- From n = 40 is λ = 1221037.2500 Å
- From n = 41 is λ = 1173702.1250 Å
- From n = 42 is λ = 1132883.7500 Å
- From n = 43 is λ = 1097352.1250 Å
- From n = 44 is λ = 1066166.8750 Å
- From n = 45 is λ = 1038597.1875 Å
- From n = 46 is λ = 1014066.2500 Å
- From n = 47 is λ = 992112.9375 Å
- From n = 48 is λ = 972364.3125 Å
- From n = 49 is λ = 954515.5625 Å
- From n = 50 is λ = 938314.8125 Å

28. λ corresponding to transition of e^- to n = 28

- From n = 29 is λ = 10547192.0000 Å
- From n = 30 is λ = 5546261.0000 Å
- From n = 31 is λ = 3881199.0000 Å
- From n = 32 is λ = 3050032.0000 Å
- From n = 33 is λ = 2552370.5000 Å
- From n = 34 is λ = 2221419.5000 Å
- From n = 35 is λ = 1985697.8750 Å
- From n = 36 is λ = 1809467.2500 Å
- From n = 37 is λ = 1672874.1250 Å
- From n = 38 is λ = 1564007.7500 Å
- From n = 39 is λ = 1475290.0000 Å
- From n = 40 is λ = 1401669.0000 Å
- From n = 41 is λ = 1339648.6250 Å
- From n = 42 is λ = 1286732.2500 Å
- From n = 43 is λ = 1241089.1250 Å
- From n = 44 is λ = 1201347.1250 Å

- From n = 45 is λ = 1166457.5000 Å
- From n = 46 is λ = 1135604.5000 Å
- From n = 47 is λ = 1108144.8750 Å
- From n = 48 is λ = 1083563.8750 Å
- From n = 49 is λ = 1061445.7500 Å
- From n = 50 is λ = 1041449.9375 Å

29. λ corresponding to transition of e^- to n = 29

- From n = 30 is λ = 11697319.0000 Å
- From n = 31 is λ = 6140983.5000 Å
- From n = 32 is λ = 4290861.5000 Å
- From n = 33 is λ = 3367222.2500 Å
- From n = 34 is λ = 2814122.0000 Å
- From n = 35 is λ = 2446247.7500 Å
- From n = 36 is λ = 2184184.0000 Å
- From n = 37 is λ = 1988223.2500 Å
- From n = 38 is λ = 1836307.7500 Å
- From n = 39 is λ = 1715204.5000 Å
- From n = 40 is λ = 1616492.8750 Å
- From n = 41 is λ = 1534560.5000 Å
- From n = 42 is λ = 1465522.5000 Å
- From n = 43 is λ = 1406604.3750 Å
- From n = 44 is λ = 1355772.5000 Å
- From n = 45 is λ = 1311501.8750 Å
- From n = 46 is λ = 1272626.8750 Å
- From n = 47 is λ = 1238241.1250 Å
- From n = 48 is λ = 1207629.5000 Å
- From n = 49 is λ = 1180220.5000 Å
- From n = 50 is λ = 1155551.2500 Å

30. λ corresponding to transition of e^- to n = 30

- From n = 31 is λ = 12928133.0000 Å

- From n = 32 is λ = 6776731.5000 Å
- From n = 33 is λ = 4728333.5000 Å
- From n = 34 is λ = 3705612.2500 Å
- From n = 35 is λ = 3093105.7500 Å
- From n = 36 is λ = 2685665.2500 Å
- From n = 37 is λ = 2395370.5000 Å
- From n = 38 is λ = 2178263.0000 Å
- From n = 39 is λ = 2009924.3750 Å
- From n = 40 is λ = 1875702.6250 Å
- From n = 41 is λ = 1766276.6250 Å
- From n = 42 is λ = 1675432.3750 Å
- From n = 43 is λ = 1598868.5000 Å
- From n = 44 is λ = 1533513.6250 Å
- From n = 45 is λ = 1477115.8750 Å
- From n = 46 is λ = 1427986.7500 Å
- From n = 47 is λ = 1384835.3750 Å
- From n = 48 is λ = 1346658.3750 Å
- From n = 49 is λ = 1312664.0000 Å
- From n = 50 is λ = 1282218.7500 Å

31. λ corresponding to transition of e^- to n = 31

- From n = 32 is λ = 14242362.0000 Å
- From n = 33 is λ = 7454880.5000 Å
- From n = 34 is λ = 5194528.5000 Å
- From n = 35 is λ = 4065884.5000 Å
- From n = 36 is λ = 3389870.2500 Å
- From n = 37 is λ = 2940128.0000 Å
- From n = 38 is λ = 2619648.0000 Å
- From n = 39 is λ = 2379929.7500 Å
- From n = 40 is λ = 2194027.2500 Å
- From n = 41 is λ = 2045776.2500 Å
- From n = 42 is λ = 1924890.2500 Å

- From n = 43 is $\lambda = 1824512.6250$ Å
- From n = 44 is $\lambda = 1739897.3750$ Å
- From n = 45 is $\lambda = 1667655.5000$ Å
- From n = 46 is $\lambda = 1605301.5000$ Å
- From n = 47 is $\lambda = 1550972.5000$ Å
- From n = 48 is $\lambda = 1503243.6250$ Å
- From n = 49 is $\lambda = 1461008.1250$ Å
- From n = 50 is $\lambda = 1423391.3750$ Å

32. λ corresponding to transition of e^- to n = 32

- From n = 33 is $\lambda = 15642783.0000$ Å
- From n = 34 is $\lambda = 8176803.0000$ Å
- From n = 35 is $\lambda = 5690357.5000$ Å
- From n = 36 is $\lambda = 4448726.0000$ Å
- From n = 37 is $\lambda = 3704963.5000$ Å
- From n = 38 is $\lambda = 3210091.5000$ Å
- From n = 39 is $\lambda = 2857409.0000$ Å
- From n = 40 is $\lambda = 2593564.2500$ Å
- From n = 41 is $\lambda = 2388921.5000$ Å
- From n = 42 is $\lambda = 2225699.0000$ Å
- From n = 43 is $\lambda = 2092582.0000$ Å
- From n = 44 is $\lambda = 1982029.1250$ Å
- From n = 45 is $\lambda = 1888819.6250$ Å
- From n = 46 is $\lambda = 1809225.0000$ Å
- From n = 47 is $\lambda = 1740511.6250$ Å
- From n = 48 is $\lambda = 1680629.6250$ Å
- From n = 49 is $\lambda = 1628012.6250$ Å
- From n = 50 is $\lambda = 1581441.7500$ Å

33. λ corresponding to transition of e^- to n = 33

- From n = 34 is $\lambda = 17132106.0000$ Å
- From n = 35 is $\lambda = 8943853.0000$ Å

- From n = 36 is λ = 6216732.0000 Å
- From n = 37 is λ = 4854818.0000 Å
- From n = 38 is λ = 4038929.5000 Å
- From n = 39 is λ = 3496012.5000 Å
- From n = 40 is λ = 3109041.5000 Å
- From n = 41 is λ = 2819508.7500 Å
- From n = 42 is λ = 2594910.0000 Å
- From n = 43 is λ = 2415743.2500 Å
- From n = 44 is λ = 2269600.2500 Å
- From n = 45 is λ = 2148209.5000 Å
- From n = 46 is λ = 2045844.8750 Å
- From n = 47 is λ = 1958417.0000 Å
- From n = 48 is λ = 1882927.7500 Å
- From n = 49 is λ = 1817129.0000 Å
- From n = 50 is λ = 1759302.1250 Å

34. λ corresponding to transition of e^- to n = 34

- From n = 35 is λ = 18713032.0000 Å
- From n = 36 is λ = 9757404.0000 Å
- From n = 37 is λ = 6774562.5000 Å
- From n = 38 is λ = 5284842.0000 Å
- From n = 39 is λ = 4392318.0000 Å
- From n = 40 is λ = 3798344.5000 Å
- From n = 41 is λ = 3374937.7500 Å
- From n = 42 is λ = 3058105.0000 Å
- From n = 43 is λ = 2812296.0000 Å
- From n = 44 is λ = 2616183.0000 Å
- From n = 45 is λ = 2456193.7500 Å
- From n = 46 is λ = 2323281.5000 Å
- From n = 47 is λ = 2211183.2500 Å
- From n = 48 is λ = 2115426.7500 Å
- From n = 49 is λ = 2032732.3750 Å

- From n = 50 is λ = 1960641.1250 Å

35. λ corresponding to transition of e^- to n = 35
    - From n = 36 is λ = 20388364.0000 Å
    - From n = 37 is λ = 10618833.0000 Å
    - From n = 38 is λ = 7364761.5000 Å
    - From n = 39 is λ = 5739489.5000 Å
    - From n = 40 is λ = 4765674.5000 Å
    - From n = 41 is λ = 4117546.5000 Å
    - From n = 42 is λ = 3655489.2500 Å
    - From n = 43 is λ = 3309695.0000 Å
    - From n = 44 is λ = 3041385.0000 Å
    - From n = 45 is λ = 2827292.2500 Å
    - From n = 46 is λ = 2652611.5000 Å
    - From n = 47 is λ = 2507473.0000 Å
    - From n = 48 is λ = 2385045.7500 Å
    - From n = 49 is λ = 2280449.7500 Å
    - From n = 50 is λ = 2190107.7500 Å
36. λ corresponding to transition of e^- to n = 36
    - From n = 37 is λ = 22160798.0000 Å
    - From n = 38 is λ = 11529485.0000 Å
    - From n = 39 is λ = 7988245.0000 Å
    - From n = 40 is λ = 6219435.0000 Å
    - From n = 41 is λ = 5159546.5000 Å
    - From n = 42 is λ = 4454073.0000 Å
    - From n = 43 is λ = 3951084.7500 Å
    - From n = 44 is λ = 3574620.2500 Å
    - From n = 45 is λ = 3282480.0000 Å
    - From n = 46 is λ = 3049344.0000 Å
    - From n = 47 is λ = 2859101.0000 Å
    - From n = 48 is λ = 2701012.0000 Å

- From n = 49 is λ = 2567642.0000 Å
- From n = 50 is λ = 2453681.0000 Å

37. λ corresponding to transition of e^- to n = 37

- From n = 38 is λ = 24033024.0000 Å
- From n = 39 is λ = 12490754.0000 Å
- From n = 40 is λ = 8645913.0000 Å
- From n = 41 is λ = 6725367.5000 Å
- From n = 42 is λ = 5574481.5000 Å
- From n = 43 is λ = 4808378.0000 Å
- From n = 44 is λ = 4262115.5000 Å
- From n = 45 is λ = 3853223.2500 Å
- From n = 46 is λ = 3535884.5000 Å
- From n = 47 is λ = 3282611.0000 Å
- From n = 48 is λ = 3075911.7500 Å
- From n = 49 is λ = 2904126.0000 Å
- From n = 50 is λ = 2759182.2500 Å

38. λ corresponding to transition of e^- to n = 38

- From n = 39 is λ = 26007934.0000 Å
- From n = 40 is λ = 13503993.0000 Å
- From n = 41 is λ = 9338694.0000 Å
- From n = 42 is λ = 7257975.0000 Å
- From n = 43 is λ = 6011027.0000 Å
- From n = 44 is λ = 5180921.5000 Å
- From n = 45 is λ = 4588975.0000 Å
- From n = 46 is λ = 4145846.5000 Å
- From n = 47 is λ = 3801903.5000 Å
- From n = 48 is λ = 3527368.5000 Å
- From n = 49 is λ = 3303292.5000 Å
- From n = 50 is λ = 3117043.5000 Å

39. λ corresponding to transition of e^- to n = 39

- From n = 40 is λ = 28088020.0000 Å
- From n = 41 is λ = 14570559.0000 Å
- From n = 42 is λ = 10067485.0000 Å
- From n = 43 is λ = 7817929.0000 Å
- From n = 44 is λ = 6469726.0000 Å
- From n = 45 is λ = 5572155.5000 Å
- From n = 46 is λ = 4932050.0000 Å
- From n = 47 is λ = 4452829.0000 Å
- From n = 48 is λ = 4080839.0000 Å
- From n = 49 is λ = 3783887.7500 Å
- From n = 50 is λ = 3541490.2500 Å

40. λ corresponding to transition of e^- to n = 40

- From n = 41 is λ = 30276262.0000 Å
- From n = 42 is λ = 15691861.0000 Å
- From n = 43 is λ = 10833210.0000 Å
- From n = 44 is λ = 8405927.0000 Å
- From n = 45 is λ = 6951134.5000 Å
- From n = 46 is λ = 5982540.0000 Å
- From n = 47 is λ = 5291734.0000 Å
- From n = 48 is λ = 4774516.5000 Å
- From n = 49 is λ = 4372997.5000 Å
- From n = 50 is λ = 4052444.5000 Å

41. λ corresponding to transition of e^- to n = 41

- From n = 42 is λ = 32575278.0000 Å
- From n = 43 is λ = 16869218.0000 Å
- From n = 44 is λ = 11636769.0000 Å
- From n = 45 is λ = 9022646.0000 Å
- From n = 46 is λ = 7455792.0000 Å
- From n = 47 is λ = 6412526.0000 Å
- From n = 48 is λ = 5668417.0000 Å

- From n = 49 is λ = 5111248.5000 Å
- From n = 50 is λ = 4678681.0000 Å

42. λ corresponding to transition of e^- to n = 42
    - From n = 43 is λ = 34987736.0000 Å
    - From n = 44 is λ = 18104012.0000 Å
    - From n = 45 is λ = 12479082.0000 Å
    - From n = 46 is λ = 9668769.0000 Å
    - From n = 47 is λ = 7984244.5000 Å
    - From n = 48 is λ = 6862571.0000 Å
    - From n = 49 is λ = 6062488.0000 Å
    - From n = 50 is λ = 5463366.0000 Å
43. λ corresponding to transition of e^- to n = 43
    - From n = 44 is λ = 37516508.0000 Å
    - From n = 45 is λ = 19397642.0000 Å
    - From n = 46 is λ = 13361064.0000 Å
    - From n = 47 is λ = 10344982.0000 Å
    - From n = 48 is λ = 8537046.0000 Å
    - From n = 49 is λ = 7333134.0000 Å
    - From n = 50 is λ = 6474340.0000 Å
44. λ corresponding to transition of e^- to n = 44
    - From n = 45 is λ = 40164312.0000 Å
    - From n = 46 is λ = 20751448.0000 Å
    - From n = 47 is λ = 14283615.0000 Å
    - From n = 48 is λ = 11051971.0000 Å
    - From n = 49 is λ = 9114739.0000 Å
    - From n = 50 is λ = 7824667.5000 Å
45. λ corresponding to transition of e^- to n = 45
    - From n = 46 is λ = 42933780.0000 Å
    - From n = 47 is λ = 22166772.0000 Å

- From n = 48 is λ = 15247650.0000 Å
- From n = 49 is λ = 11790411.0000 Å
- From n = 50 is λ = 9717867.0000 Å

46. λ corresponding to transition of e^- to n = 46
    - From n = 47 is λ = 45827660.0000 Å
    - From n = 48 is λ = 23645026.0000 Å
    - From n = 49 is λ = 16254083.0000 Å
    - From n = 50 is λ = 12560991.0000 Å
47. λ corresponding to transition of e^- to n = 47
    - From n = 48 is λ = 48848848.0000 Å
    - From n = 49 is λ = 25187572.0000 Å
    - From n = 50 is λ = 17303832.0000 Å
48. λ corresponding to transition of e^- to n = 48
    - From n = 49 is λ = 51999896.0000 Å
    - From n = 50 is λ = 26795744.0000 Å
49. λ corresponding to transition of e^- to n = 49
    - From n = 50 is λ = 55283588.0000 Å

14 Problem 11

14.1 Question

Problem 11

Prepare a program to read a matrix A and B of order 6 x 6 and calculate their sum and print it.

Also in the same program obtain the trace of each matrix (i.e. sum of all the diagonal elements) and print their values using an E format.

14.2 Solution

14.2.1 Source Code

```
program P11

    implicit none
    real :: TrA=0, TrB=0
    real, dimension(6,6) :: A, B, Sum
    integer :: i, j

    open(unit=999, status="old", file="A.dat")
    read(999, *) A
    close(999)
    open(unit=997, status="old", file="B.dat")
    read(997, *) B
    close(997)

    do i=1,6
    do j=1,6
    Sum(i,j) = A(i,j) + B(i,j)
    if (i == j) then
    TrA = TrA + A(i,j)
    TrB = TrB + B(i,j)
    end if
    end do
    end do

    open(unit=998, status="old", file="output.dat")
    write(998, *) "Trace of A = ", TrA
    write(998, *) "Trace of B = ", TrB
    open(unit=996, status="old", file="Sum.dat")
    do i=1,6
    write(996, *) Sum(i,:)
    end do

end program P11
```

14.2.2 Input File

```
cat A.dat
```

$$\begin{bmatrix} 1 & 2 & 3 & 4 & 5 & 6 \\ 2 & 4 & 6 & 8 & 10 & 12 \\ 3 & 6 & 9 & 12 & 15 & 18 \\ 4 & 8 & 12 & 16 & 20 & 24 \\ 5 & 10 & 15 & 20 & 25 & 30 \\ 6 & 12 & 18 & 24 & 30 & 36 \end{bmatrix}$$

```
cat B.dat
```

$$\begin{bmatrix} 10 & 20 & 30 & 40 & 50 & 60 \\ 11 & 22 & 33 & 44 & 55 & 66 \\ 2 & 4 & 6 & 8 & 10 & 12 \\ 7 & 14 & 21 & 28 & 35 & 42 \\ 8 & 16 & 24 & 32 & 40 & 48 \\ 9 & 18 & 27 & 36 & 45 & 54 \end{bmatrix}$$

14.2.3 Output File

```
cat output.dat
```

$$\begin{array}{llll} \text{Trace} & \text{of} & \text{A} & = & 91.0 \\ \text{Trace} & \text{of} & \text{B} & = & 160.0 \end{array}$$

```
cat Sum.dat
```

$$\begin{bmatrix} 11.0 & 13.0 & 5.0 & 11.0 & 13.0 & 15.0 \\ 22.0 & 26.0 & 10.0 & 22.0 & 26.0 & 30.0 \\ 33.0 & 39.0 & 15.0 & 33.0 & 39.0 & 45.0 \\ 44.0 & 52.0 & 20.0 & 44.0 & 52.0 & 60.0 \\ 55.0 & 65.0 & 25.0 & 55.0 & 65.0 & 75.0 \\ 66.0 & 78.0 & 30.0 & 66.0 & 78.0 & 90.0 \end{bmatrix}$$

15 Problem 12

15.1 Question

Problem 12

Make a computer program by taking three matrices A, B and C of appropriate orders and read their elements and then multiply them to obtain a matrix D. Print its elements.

15.2 Solution

15.2.1 Source Code

```
program P12

    implicit none
    real, dimension(:,:), allocatable :: A, B, C, D, T
    integer :: Ai, Aj, Bi, Bj, Ci, Cj, i, j, m, n
    real :: k = 0

    open(unit=998, status="old", file="input.dat")
    read(998, *) Ai, Aj
    read(998, *) Bi, Bj
    read(998, *) Ci, Cj
    close(998)

    print *, "Order of *A* = ", Ai, Aj
    print *, "Order of *B* = ", Bi, Bj
    print *, "Order of *C* = ", Ci, Cj


    if((Aj == Bi) .and. (Bj == Ci)) then
    allocate(A(1:Ai,1:Aj))
    allocate(B(1:Bi,1:Bj))
    allocate(C(1:Ci,1:Cj))
    allocate(T(1:Ai,1:Bj))
    allocate(D(1:Ai,1:Cj))

    open(unit=997, status="old", file="A.dat")
    do i=1,Ai
    read(997, *) A(i,:)
    end do
    close(997)
    open(unit=996, status="old", file="B.dat")
    do i=1,Bi
    read(996, *) B(i,:)
    end do
    close(996)
    open(unit=999, status="old", file="C.dat")
```

```
    do i=1,Ci
    read(999, *) C(i,:)
    end do
    close(999)

    T = matmul(A,B)
    D = matmul(T,C)

    open(unit=995, status="old", file="output.dat")
    do i=1,Ai
    write(995, *) D(i,1:Cj)
    end do

    else
    write(995, *) "The Orders of Matrices are not in order for
↪   Matrix Multiplication"
    end if

    deallocate(A)
    deallocate(B)
    deallocate(C)
    deallocate(T)
    deallocate(D)

end program P12
```

$$\begin{array}{lllllll} \text{Order} & \text{of} & \mathbf{A} & = & 2 & 2 \\ \text{Order} & \text{of} & \mathbf{B} & = & 2 & 2 \\ \text{Order} & \text{of} & \mathbf{C} & = & 2 & 2 \end{array}$$

15.2.2 Input File

```
cat input.dat
```

$$\begin{array}{ll} 2 & 2 \\ 2 & 2 \\ 2 & 2 \end{array}$$

```
cat A.dat
```

$$\begin{bmatrix} 2 & 5 \\ 3 & 7 \end{bmatrix}$$

```
cat B.dat
```

$$\begin{bmatrix} 3 & 8 \\ 2 & 1 \end{bmatrix}$$

```
cat C.dat
```

$$\begin{bmatrix} 9 & 2 \\ 1 & 3 \end{bmatrix}$$

15.2.3 Output File

```
cat output.dat
```

$$\begin{bmatrix} 165.0 & 95.0 \\ 238.0 & 139.0 \end{bmatrix}$$

16 Problem 13

16.1 Question

Problem 13

Make a function subprogram to evaluate second order determinant and utilize it to obtain the value of a third order determinant.

16.2 Solution

16.2.1 Source Code

```
module det2x2

    contains
    real function det(A)

        implicit none
        real, dimension(2,2) :: A
        det = (((A(1,1))*(A(2,2)))-((A(1,2))*(A(2,1))))

    end function det

end module det2x2
```

```
program P13

    use det2x2
    implicit none
    real, dimension(3,3) :: A
    real, dimension(2,2) :: A11, A12, A13
    real :: delta, M11, M12, M13

    open(unit=998, status="old", file="input.dat")
    read(998, *) A
    close(998)

    A11 = A(2:3,2:3)
    A13 = A(2:3,1:2)
    A12(:,1) = A(2:3,1)
    A12(:,2) = A(2:3,3)

    M11 = det(A11)
    M12 = det(A12)
    M13 = det(A13)

    delta = ((A(1,1))*M11)-((A(1,2))*M12)+((A(1,3))*M13)

    open(unit=999, status="old", file="output.dat")
    write(999, "(a, 1f5.1)") "Determinant \Delta = ", delta

end program P13
```

16.2.2 Input File

```
cat input.dat
```

$$\begin{bmatrix} 5 & 6 & 2 \\ 1 & 0 & 5 \\ 2 & 1 & 1 \end{bmatrix}$$

16.2.3 Output File

```
cat output.dat
```

Determinant $\Delta = 31.0$

17 Problem 14

17.1 Question

Problem 14

Write a subprogram which calculates the spherical coordinates (r, theta and phi) of a given point in Cartesian coordinates (x, y, z) using their usual relations

17.2 Solution

17.2.1 Source Code

```
program P14

    implicit none
    real :: x, y, z
    real :: r, t, p
    real :: td, pd
    real, parameter :: pi = 3.14159265
    open(unit=999, status="old", file="input.dat")
    read(999, *) x, y, z
    close(999)

    r = sqrt((x**2)+(y**2)+(z**2))
    t = atan(y/x)
    p = atan(z/sqrt((x**2)+(y**2)))

    open(unit=998, status="old", file="output.dat")
    write(998, "(a, 1f6.3, a, 1f6.3, a, 1f6.3, a)")
    ↪  "(r,\theta,\phi) = (", r, ",", t, ",", p, ")"

end program P14
```

17.2.2 Input File

```
cat input.dat

1 1 1
```

17.2.3 Output File

```
cat output.dat
```

$(r,\theta,\phi) = (\ 1.732,\ 0.785,\ 0.615)$