Exercise 1

Enter the height of the tower (in m) : 100
The time that the ball takes to reach the ground is (in sec) : 4.516

Exercise 2

1 day (86400 sec) : The altitude of the satellite is 35862994.1977 meters
90 minutes (5400 sec) : The altitude of the satellite is 274455.4688
meters
45 minutes (2700 sec) : This time period is not physically possible!

Thus the trend that we observe here is time period increases with height
and there exists a lower bound on T_min such that values
of T < T_min are not physically realisable as it implies that h is
negative which is against our initial assumption. Thus 45 minutes
is one such example of T < T_min

The sidereal day is the time required for the Earth to rotate once
relative to the background of the stars (which remains fixed) â€"i.e.,
the time between two observed passages of a star over the same meridian
of longitude. This is 23.94 hours long. However a solar day
is when the Earth completes one full rotation with respect to Sun, but it
is longer than sidereal day as the Earth also revolves
around the Sun so we have to consider the extra rotation for the Earth to
reach the initial position. This is 24 hours long. Hence
a sidereal day is the true time period of rotation of the Earth

1 sidereal day (86184 sec) : The altitude of the satellite is
35792563.0073 meters
1 solar day (86400 sec) : The altitude of the satellite is 35862994.1977
meters

Thus there is a difference of 70,431.1904 meters

Hence a geosyncronous satellite is placed at a height of 35792563.0073
meters

Exercise 4

Enter the value of distance in light years:10
Enter the value of speed as a fraction of the speed of light c:0.99
Time observed by an observer at rest on Earth is 10.1010 years
Time observed by an observer on ship is 1.4249 years

Exercise 5

For the given Energy and Step potential the transmission probability is 0.73013 and the reflection probability is 0.26987

```
Exercise 6

Earth:
Enter the perihelion distance (in m): 1.471e+11
Enter the perihelion velocity at perihelion (in m/s): 3.0287e+4
The Aphelion distance: 152111350728.5926 m
The Aphelion velocity: 29289.1864 m/s
The Orbital period: 1.0001 year
The Eccentricity: 0.0167

Halley's Comet:
Enter the perihelion distance (in m): 8.783e+10
Enter the perihelion velocity at perihelion (in m/s): 5.4529e+4
The Aphelion distance: 5371566481143.3535 m
The Aphelion velocity: 891.5988 m/s
The Orbital period: 77.9457 year
The Eccentricity: 0.9678
```

Exercise 7

1
2.0
5.0
14.0
42.0
132.0
429.0
1430.0
4862.0
16796.0
58786.0
208012.0
742900.0
2674440.0
9694845.0
35357670.0
129644790.0
477638700.0

Exercise 8

Computed value:
The value of Madelung constant for NaCl is: -1.7418198158396654

Literature value of Madelung constant for NaCl: ±1.747565

```
Exercise 9

Enter the Atomic Number: 28
Enter the Mass Number: 58
The binding energy of an atom with A = 58.0 and Z = 28 is
493.93560680136824 MeV
The binding energy per nucleon of an atom with A = 58.0 and Z = 28 is
8.516131151747729 MeV
The most stable mass number for Z = 28 is A = 58 and the corresponding
binding energy per nucleon is 8.51613 MeV
The maximum binding energy per nucleon for Z = 1 is -2.5457 with
corresponding A = 2
The maximum binding energy per nucleon for Z = 2 is 5.8433 with
corresponding A = 4
The maximum binding energy per nucleon for Z = 3 is 4.7524 with
corresponding A = 6
The maximum binding energy per nucleon for Z = 4 is 6.8353 with
corresponding A = 8
The maximum binding energy per nucleon for Z = 5 is 6.4228 with
corresponding A = 10
The maximum binding energy per nucleon for Z = 6 is 7.4500 with
corresponding A = 12
The maximum binding energy per nucleon for Z = 7 is 7.2759 with
corresponding A = 15
The maximum binding energy per nucleon for Z = 8 is 7.8292 with
corresponding A = 16
The maximum binding energy per nucleon for Z = 9 is 7.7565 with
corresponding A = 19
The maximum binding energy per nucleon for Z = 10 is 8.0751 with
corresponding A = 20
The maximum binding energy per nucleon for Z = 11 is 8.0477 with
corresponding A = 23
The maximum binding energy per nucleon for Z = 12 is 8.2387 with
corresponding A = 24
The maximum binding energy per nucleon for Z = 13 is 8.2340 with
corresponding A = 27
The maximum binding energy per nucleon for Z = 14 is 8.3479 with
corresponding A = 28
The maximum binding energy per nucleon for Z = 15 is 8.3553 with
corresponding A = 31
The maximum binding energy per nucleon for Z = 16 is 8.4193 with
corresponding A = 32
The maximum binding energy per nucleon for Z = 17 is 8.4333 with
corresponding A = 35
The maximum binding energy per nucleon for Z = 18 is 8.4631 with
corresponding A = 36
The maximum binding energy per nucleon for Z = 19 is 8.4808 with
corresponding A = 39
The maximum binding energy per nucleon for Z = 20 is 8.4958 with
corresponding A = 41
The maximum binding energy per nucleon for Z = 21 is 8.5060 with
corresponding A = 43
The maximum binding energy per nucleon for Z = 22 is 8.5211 with
corresponding A = 46
The maximum binding energy per nucleon for Z = 23 is 8.5143 with
corresponding A = 47
The maximum binding energy per nucleon for Z = 24 is 8.5326 with
corresponding A = 50
The maximum binding energy per nucleon for Z = 25 is 8.5095 with
corresponding A = 51
```

The maximum binding energy per nucleon for Z = 26 is 8.5299 with corresponding A = 54
The maximum binding energy per nucleon for Z = 27 is 8.4945 with corresponding A = 55
The maximum binding energy per nucleon for Z = 28 is 8.5161 with corresponding A = 58
The maximum binding energy per nucleon for Z = 29 is 8.4712 with corresponding A = 59
The maximum binding energy per nucleon for Z = 30 is 8.4935 with corresponding A = 62
The maximum binding energy per nucleon for Z = 31 is 8.4412 with corresponding A = 63
The maximum binding energy per nucleon for Z = 32 is 8.4639 with corresponding A = 66
The maximum binding energy per nucleon for Z = 33 is 8.4070 with corresponding A = 69
The maximum binding energy per nucleon for Z = 34 is 8.4284 with corresponding A = 70
The maximum binding energy per nucleon for Z = 35 is 8.3785 with corresponding A = 73
The maximum binding energy per nucleon for Z = 36 is 8.3881 with corresponding A = 74
The maximum binding energy per nucleon for Z = 37 is 8.3442 with corresponding A = 77
The maximum binding energy per nucleon for Z = 38 is 8.3439 with corresponding A = 78
The maximum binding energy per nucleon for Z = 39 is 8.3050 with corresponding A = 81
The maximum binding energy per nucleon for Z = 40 is 8.2963 with corresponding A = 82
The maximum binding energy per nucleon for Z = 41 is 8.2618 with corresponding A = 85
The maximum binding energy per nucleon for Z = 42 is 8.2459 with corresponding A = 86
The maximum binding energy per nucleon for Z = 43 is 8.2151 with corresponding A = 89
The maximum binding energy per nucleon for Z = 44 is 8.1946 with corresponding A = 92
The maximum binding energy per nucleon for Z = 45 is 8.1656 with corresponding A = 93
The maximum binding energy per nucleon for Z = 46 is 8.1477 with corresponding A = 96
The maximum binding energy per nucleon for Z = 47 is 8.1136 with corresponding A = 97
The maximum binding energy per nucleon for Z = 48 is 8.0979 with corresponding A = 100
The maximum binding energy per nucleon for Z = 49 is 8.0595 with corresponding A = 101
The maximum binding energy per nucleon for Z = 50 is 8.0458 with corresponding A = 104
The maximum binding energy per nucleon for Z = 51 is 8.0036 with corresponding A = 105
The maximum binding energy per nucleon for Z = 52 is 7.9917 with corresponding A = 108
The maximum binding energy per nucleon for Z = 53 is 7.9465 with corresponding A = 111
The maximum binding energy per nucleon for Z = 54 is 7.9358 with corresponding A = 112
The maximum binding energy per nucleon for Z = 55 is 7.8938 with corresponding A = 115

The maximum binding energy per nucleon for Z = 56 is 7.8784 with corresponding A = 116
The maximum binding energy per nucleon for Z = 57 is 7.8394 with corresponding A = 119
The maximum binding energy per nucleon for Z = 58 is 7.8198 with corresponding A = 120
The maximum binding energy per nucleon for Z = 59 is 7.7834 with corresponding A = 123
The maximum binding energy per nucleon for Z = 60 is 7.7600 with corresponding A = 124
The maximum binding energy per nucleon for Z = 61 is 7.7260 with corresponding A = 127
The maximum binding energy per nucleon for Z = 62 is 7.7005 with corresponding A = 130
The maximum binding energy per nucleon for Z = 63 is 7.6675 with corresponding A = 131
The maximum binding energy per nucleon for Z = 64 is 7.6438 with corresponding A = 134
The maximum binding energy per nucleon for Z = 65 is 7.6079 with corresponding A = 135
The maximum binding energy per nucleon for Z = 66 is 7.5858 with corresponding A = 138
The maximum binding energy per nucleon for Z = 67 is 7.5474 with corresponding A = 139
The maximum binding energy per nucleon for Z = 68 is 7.5269 with corresponding A = 142
The maximum binding energy per nucleon for Z = 69 is 7.4861 with corresponding A = 143
The maximum binding energy per nucleon for Z = 70 is 7.4670 with corresponding A = 146
The maximum binding energy per nucleon for Z = 71 is 7.4280 with corresponding A = 149
The maximum binding energy per nucleon for Z = 72 is 7.4063 with corresponding A = 150
The maximum binding energy per nucleon for Z = 73 is 7.3693 with corresponding A = 153
The maximum binding energy per nucleon for Z = 74 is 7.3449 with corresponding A = 154
The maximum binding energy per nucleon for Z = 75 is 7.3098 with corresponding A = 157
The maximum binding energy per nucleon for Z = 76 is 7.2829 with corresponding A = 158
The maximum binding energy per nucleon for Z = 77 is 7.2496 with corresponding A = 161
The maximum binding energy per nucleon for Z = 78 is 7.2231 with corresponding A = 164
The maximum binding energy per nucleon for Z = 79 is 7.1887 with corresponding A = 165
The maximum binding energy per nucleon for Z = 80 is 7.1636 with corresponding A = 168
The maximum binding energy per nucleon for Z = 81 is 7.1273 with corresponding A = 169
The maximum binding energy per nucleon for Z = 82 is 7.1034 with corresponding A = 172
The maximum binding energy per nucleon for Z = 83 is 7.0653 with corresponding A = 173
The maximum binding energy per nucleon for Z = 84 is 7.0426 with corresponding A = 176
The maximum binding energy per nucleon for Z = 85 is 7.0056 with corresponding A = 179

The maximum binding energy per nucleon for Z = 86 is 6.9813 with corresponding A = 180
The maximum binding energy per nucleon for Z = 87 is 6.9459 with corresponding A = 183
The maximum binding energy per nucleon for Z = 88 is 6.9196 with corresponding A = 184
The maximum binding energy per nucleon for Z = 89 is 6.8856 with corresponding A = 187
The maximum binding energy per nucleon for Z = 90 is 6.8576 with corresponding A = 190
The maximum binding energy per nucleon for Z = 91 is 6.8249 with corresponding A = 191
The maximum binding energy per nucleon for Z = 92 is 6.7980 with corresponding A = 194
The maximum binding energy per nucleon for Z = 93 is 6.7637 with corresponding A = 195
The maximum binding energy per nucleon for Z = 94 is 6.7380 with corresponding A = 198
The maximum binding energy per nucleon for Z = 95 is 6.7021 with corresponding A = 199
The maximum binding energy per nucleon for Z = 96 is 6.6774 with corresponding A = 202
The maximum binding energy per nucleon for Z = 97 is 6.6415 with corresponding A = 205
The maximum binding energy per nucleon for Z = 98 is 6.6165 with corresponding A = 206
The maximum binding energy per nucleon for Z = 99 is 6.5819 with corresponding A = 209
The maximum binding energy per nucleon for Z = 100 is 6.5553 with corresponding A = 210
The element with the maximum binding energy per nucleon is Z = 24 with A = 50 and corresponding binding energy per nucleon is 8.53262 MeV

```
Exercise 10

1 1

1 2 1

1 3 3 1

1 4 6 4 1

1 5 10 10 5 1

1 6 15 20 15 6 1

1 7 21 35 35 21 7 1

1 8 28 56 70 56 28 8 1

1 9 36 84 126 126 84 36 9 1

1 10 45 120 210 252 210 120 45 10 1

1 11 55 165 330 461 461 329 164 54 10 0

1 12 66 220 495 792 924 792 495 220 66 12 1

1 13 78 286 715 1287 1716 1716 1287 715 286 78 13 1

1 14 91 364 1001 2002 3003 3432 3003 2002 1001 364 91 14 1

1 15 105 454 1364 3002 5004 6434 6434 5004 3002 1364 454 104 14 0

1 16 120 560 1820 4368 8008 11440 12870 11440 8007 4367 1819 560 120 16 1

1 17 136 680 2380 6188 12376 19448 24310 24310 19448 12376 6188 2380 680
136 17 1

1 18 153 816 3060 8568 18564 31824 43758 48620 43758 31824 18564 8568
3060 816 153 18 1

1 19 171 969 3876 11628 27132 50388 75582 92378 92378 75582 50388 27132
11628 3876 969 171 19 1

1 20 190 1140 4845 15504 38760 77520 125970 167960 184756 167960 125970
77520 38760 15504 4845 1140 190 20 1

The probability that an unbiased coin, tossed 100 times, will come up
heads exactly 60 times is 0.0108439
The probability that it comes up heads 60 or more times is 0.0284440
```

Exercise 11

[2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37, 41, 43, 47, 53, 59, 61, 67,
71, 73, 79, 83, 89, 97, 101, 103, 107, 109, 113, 127, 131, 137, 139,
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9787, 9791, 9803, 9811, 9817, 9829, 9833, 9839, 9851, 9857, 9859, 9871,
9883, 9887, 9901, 9907, 9923, 9929, 9931, 9941, 9949, 9967, 9973]

```
Exercise 12

The 100th Catalan Number is:
896519947090131678185430741499021921911623568450622849024
The GCD of 108 and 192 is  12
```

Exercise 16

Part A

Fixed Points:
In the Feigenbaum plot the points at which for a given value of r there
is a single value of x are called fixed points, the range of
values of r which produces fixed point is approximately r = 1 to r = 3.

Limit cycles:
In the Feigenbaum plot the points at which for a given value of r the
value of x oscillates between two values for r in the range 3 to 3.5
(approximately), similarly for values of r slightly above 3.5, x
oscillates between 4 points, and again for greater values of r x
oscillates between 8,16,32,... points.

Chaos:
After a certain threshold of r, x now takes seemingly infinite values at
each point, but we can always algorithmically obtain any point in
the Feigenbaum plot using the logistic equation. Thus we call it
deterministic chaos.

Part B

The value at which the system moves from orderly behavior (fixed points
or limit cycles) to chaotic behavior is(approximately) r = 3.57