CSE 4309 Assignment 5

Inshaad Merchant - 1001861293

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Task 1:

The Python file is attached to this document.

Optimized with pruning threshold of 50

```
tree=1, node=1, feature=15, thr= 24.50, gain=0.622315
tree=1, node=2, feature=4, thr= 40.50, gain=0.587774
tree=1, node=4, feature=9, thr= 18.50, gain=0.694970
tree=1, node=8, feature=14, thr= 54.50, gain=0.484033
tree=1, node=16, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=17, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=9, feature=5, thr= 64.50, gain=0.624701
tree=1, node=18, feature=15, thr=  1.00, gain=0.203643
tree=1, node=36, feature=9, thr= 82.50, gain=0.111601
tree=1, node=72, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=73, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=37, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=19, feature=9, thr= 61.50, gain=0.527032
tree=1, node=38, feature=14, thr= 26.00, gain=0.761426
tree=1, node=76, feature=7, thr= 72.00, gain=0.488771
tree=1, node=152, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=153, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=77, feature=7, thr= 54.50, gain=0.841667
tree=1, node=154, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=155, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=39, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=5, feature=10, thr= 38.50, gain=0.621049
tree=1, node=10, feature=14, thr= 37.50, gain=0.224463
tree=1, node=20, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=21, feature=8, thr= 34.50, gain=0.140854
tree=1, node=42, feature=9, thr=  1.50, gain=0.074757
tree=1, node=84, feature=8, thr= 12.00, gain=0.365288
tree=1, node=168, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=169, feature=-1, thr= -1.00, gain=0.000000
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tree=1, node=85, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=43, feature=6, thr= 68.50, gain=0.275736
tree=1, node=86, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=87, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=11, feature=3, thr= 90.50, gain=0.685047
tree=1, node=22, feature=6, thr= 71.50, gain=0.523322
tree=1, node=44, feature=15, thr= 10.00, gain=0.336642
tree=1, node=88, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=89, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=45, feature=1, thr= 79.50, gain=0.343449
tree=1, node=90, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=91, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=23, feature=7, thr= 76.50, gain=0.395504
tree=1, node=46, feature=2, thr= 89.50, gain=0.247191
tree=1, node=92, feature=9, thr= 23.00, gain=0.226290
tree=1, node=184, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=185, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=93, feature=5, thr= 85.00, gain=0.891051
tree=1, node=186, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=187, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=47, feature=5, thr= 89.50, gain=0.778977
tree=1, node=94, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=95, feature=6, thr= 72.50, gain=0.981132
tree=1, node=190, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=191, feature=11, thr= 39.50, gain=0.549553
tree=1, node=382, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=383, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=3, feature=13, thr= 57.50, gain=0.693090
tree=1, node=6, feature=0, thr= 35.50, gain=0.704917
tree=1, node=12, feature=14, thr= 38.50, gain=0.252781
tree=1, node=24, feature=1, thr= 84.50, gain=0.549200
tree=1, node=48, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=49, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=25, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=13, feature=10, thr= 33.50, gain=0.595866
tree=1, node=26, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=27, feature=9, thr= 19.50, gain=0.423288
tree=1, node=54, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=55, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=7, feature=8, thr= 56.50, gain=0.799162
tree=1, node=14, feature=14, thr= 96.00, gain=0.723674
tree=1, node=28, feature=11, thr= 31.50, gain=0.166116
tree=1, node=56, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=57, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=29, feature=13, thr= 72.50, gain=0.380947
tree=1, node=58, feature=-1, thr= -1.00, gain=0.000000
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tree=1, node=59, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=15, feature=7, thr= 26.50, gain=0.231693
tree=1, node=30, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=31, feature=3, thr= 31.00, gain=0.970951
tree=1, node=62, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=63, feature=-1, thr= -1.00, gain=0.000000
...................Model Training Complete.....................
classification accuracy=0.8591
```

1 decision forest with pruning threshold of 50

```
tree=1, node=1, feature=7, thr= 47.50, gain=0.473234
tree=1, node=2, feature=11, thr= 37.50, gain=0.645402
tree=1, node=4, feature=9, thr=  6.50, gain=0.280207
tree=1, node=8, feature=3, thr= 96.50, gain=0.501600
tree=1, node=16, feature=14, thr= 37.50, gain=0.440423
tree=1, node=32, feature=12, thr= 53.50, gain=0.012080
tree=1, node=64, feature=5, thr= 55.50, gain=0.027263
tree=1, node=128, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=129, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=65, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=33, feature=0, thr= 30.00, gain=0.514686
tree=1, node=66, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=67, feature=14, thr= 81.00, gain=0.419563
tree=1, node=134, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=135, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=17, feature=15, thr= 21.50, gain=0.710980
tree=1, node=34, feature=10, thr= 37.00, gain=0.673452
tree=1, node=68, feature=8, thr= 18.50, gain=0.341367
tree=1, node=136, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=137, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=69, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=35, feature=1, thr= 79.50, gain=0.268023
tree=1, node=70, feature=13, thr= 50.50, gain=0.156928
tree=1, node=140, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=141, feature=8, thr= 67.50, gain=0.086694
tree=1, node=282, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=283, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=71, feature=1, thr= 97.50, gain=0.058790
tree=1, node=142, feature=7, thr= 33.50, gain=0.127328
tree=1, node=284, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=285, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=143, feature=11, thr= 23.50, gain=0.159333
tree=1, node=286, feature=1, thr= 99.50, gain=0.056703
tree=1, node=572, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=573, feature=-1, thr= -1.00, gain=0.000000
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tree=1, node=287, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=9, feature=14, thr= 55.00, gain=0.698655
tree=1, node=18, feature=6, thr= 35.50, gain=0.555514
tree=1, node=36, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=37, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=19, feature=12, thr= 39.50, gain=0.404035
tree=1, node=38, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=39, feature=6, thr= 23.00, gain=0.393840
tree=1, node=78, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=79, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=5, feature=3, thr= 69.50, gain=0.266604
tree=1, node=10, feature=3, thr= 49.50, gain=0.135558
tree=1, node=20, feature=0, thr= 37.50, gain=0.085955
tree=1, node=40, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=41, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=21, feature=13, thr= 60.50, gain=0.514867
tree=1, node=42, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=43, feature=4, thr= 33.50, gain=0.789419
tree=1, node=86, feature=3, thr= 59.50, gain=0.011923
tree=1, node=172, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=173, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=87, feature=0, thr= 55.50, gain=0.114447
tree=1, node=174, feature=11, thr= 77.50, gain=0.081558
tree=1, node=348, feature=9, thr= 23.50, gain=0.162417
tree=1, node=696, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=697, feature=4, thr= 87.50, gain=0.307239
tree=1, node=1394, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=1395, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=349, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=175, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=11, feature=7, thr= 14.50, gain=0.817384
tree=1, node=22, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=23, feature=3, thr= 96.50, gain=0.180696
tree=1, node=46, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=47, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=3, feature=4, thr= 48.50, gain=0.288608
tree=1, node=6, feature=5, thr= 64.50, gain=0.418446
tree=1, node=12, feature=9, thr= 91.50, gain=0.196929
tree=1, node=24, feature=0, thr= 72.50, gain=0.172657
tree=1, node=48, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=49, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=25, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=13, feature=6, thr= 50.50, gain=0.191307
tree=1, node=26, feature=6, thr= 19.50, gain=0.142297
tree=1, node=52, feature=4, thr= 10.50, gain=0.158522
tree=1, node=104, feature=-1, thr= -1.00, gain=0.000000
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tree=1, node=105, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=53, feature=3, thr= 93.50, gain=0.215421
tree=1, node=106, feature=14, thr= 98.50, gain=0.401168
tree=1, node=212, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=213, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=107, feature=7, thr= 56.50, gain=0.221521
tree=1, node=214, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=215, feature=13, thr=  4.50, gain=0.425323
tree=1, node=430, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=431, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=27, feature=15, thr=  0.50, gain=0.098982
tree=1, node=54, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=55, feature=12, thr= 46.50, gain=0.185573
tree=1, node=110, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=111, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=7, feature=4, thr= 78.50, gain=0.069831
tree=1, node=14, feature=12, thr= 33.50, gain=0.074077
tree=1, node=28, feature=14, thr= 37.50, gain=0.363460
tree=1, node=56, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=57, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=29, feature=7, thr= 77.50, gain=0.537729
tree=1, node=58, feature=14, thr= 82.50, gain=0.902047
tree=1, node=116, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=117, feature=9, thr= 16.50, gain=0.225163
tree=1, node=234, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=235, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=59, feature=0, thr=  6.50, gain=0.735681
tree=1, node=118, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=119, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=15, feature=12, thr= 30.50, gain=0.243054
tree=1, node=30, feature=13, thr= 25.50, gain=0.577035
tree=1, node=60, feature=15, thr= 11.50, gain=0.624466
tree=1, node=120, feature=7, thr= 77.50, gain=0.258881
tree=1, node=240, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=241, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=121, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=61, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=31, feature=10, thr= 49.50, gain=0.401243
tree=1, node=62, feature=9, thr= 44.50, gain=0.449976
tree=1, node=124, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=125, feature=5, thr= 92.50, gain=0.338279
tree=1, node=250, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=251, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=63, feature=5, thr= 90.50, gain=0.188968
tree=1, node=126, feature=11, thr= 30.50, gain=0.594025
tree=1, node=252, feature=-1, thr= -1.00, gain=0.000000
```

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tree=1, node=253, feature=0, thr=  4.50, gain=0.451936
tree=1, node=506, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=507, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=127, feature=8, thr= 61.50, gain=0.321233
tree=1, node=254, feature=13, thr= 21.00, gain=0.592951
tree=1, node=508, feature=8, thr= 41.50, gain=0.341253
tree=1, node=1016, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=1017, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=509, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=255, feature=6, thr= 72.50, gain=0.470516
tree=1, node=510, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=511, feature=4, thr= 83.50, gain=0.060940
tree=1, node=1022, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=1023, feature=10, thr= 86.50, gain=0.267491
tree=1, node=2046, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=2047, feature=-1, thr= -1.00, gain=0.000000
...................Model Training Complete.....................
classification accuracy=0.7307
```

3 decision forests with pruning threshold of 50

```
tree=1, node=1, feature=15, thr= 24.50, gain=0.622315
tree=1, node=2, feature=12, thr= 68.50, gain=0.171795
tree=1, node=4, feature=12, thr= 25.50, gain=0.112651
tree=1, node=8, feature=12, thr= 11.50, gain=0.082028
tree=1, node=16, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=17, feature=3, thr= 89.50, gain=0.361031
tree=1, node=34, feature=13, thr= 26.50, gain=0.516649
tree=1, node=68, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=69, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=35, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=9, feature=8, thr= 60.50, gain=0.494996
tree=1, node=18, feature=9, thr= 35.50, gain=0.550605
tree=1, node=36, feature=7, thr= 32.50, gain=0.236542
tree=1, node=72, feature=7, thr= 22.50, gain=0.052452
tree=1, node=144, feature=15, thr= 12.50, gain=0.085502
tree=1, node=288, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=289, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=145, feature=15, thr=  7.50, gain=0.245521
tree=1, node=290, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=291, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=73, feature=15, thr= 12.50, gain=0.249436
tree=1, node=146, feature=8, thr= 34.50, gain=0.165199
tree=1, node=292, feature=5, thr= 77.50, gain=0.045504
tree=1, node=584, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=585, feature=8, thr= 18.50, gain=0.022943
```

```
tree=1, node=1170, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=1171, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=293, feature=1, thr= 74.50, gain=0.140345
tree=1, node=586, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=587, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=147, feature=1, thr= 84.00, gain=0.577603
tree=1, node=294, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=295, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=37, feature=11, thr= 49.00, gain=0.501271
tree=1, node=74, feature=7, thr= 79.50, gain=0.268177
tree=1, node=148, feature=0, thr= 27.50, gain=0.486282
tree=1, node=296, feature=10, thr= 59.00, gain=0.940317
tree=1, node=592, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=593, feature=10, thr= 99.00, gain=0.074169
tree=1, node=1186, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=1187, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=297, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=149, feature=10, thr= 79.50, gain=0.334884
tree=1, node=298, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=299, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=75, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=19, feature=6, thr= 85.50, gain=0.368050
tree=1, node=38, feature=7, thr= 46.50, gain=0.476532
tree=1, node=76, feature=11, thr= 42.50, gain=0.713735
tree=1, node=152, feature=15, thr=  0.50, gain=0.247203
tree=1, node=304, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=305, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=153, feature=10, thr= 99.50, gain=0.040229
tree=1, node=306, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=307, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=77, feature=13, thr= 15.50, gain=0.369975
tree=1, node=154, feature=3, thr= 91.00, gain=0.217772
tree=1, node=308, feature=3, thr= 76.50, gain=0.125369
tree=1, node=616, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=617, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=309, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=155, feature=8, thr= 99.50, gain=0.213002
tree=1, node=310, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=311, feature=10, thr= 74.50, gain=0.209016
tree=1, node=622, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=623, feature=7, thr= 67.50, gain=0.805800
tree=1, node=1246, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=1247, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=39, feature=5, thr= 74.50, gain=0.502582
tree=1, node=78, feature=3, thr= 77.50, gain=0.594374
tree=1, node=156, feature=-1, thr= -1.00, gain=0.000000
```

```
tree=1, node=157, feature=3, thr= 90.50, gain=0.214716
tree=1, node=314, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=315, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=79, feature=3, thr= 88.00, gain=0.752906
tree=1, node=158, feature=12, thr= 51.50, gain=0.018523
tree=1, node=316, feature=11, thr= 46.50, gain=0.142329
tree=1, node=632, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=633, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=317, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=159, feature=6, thr= 94.50, gain=0.188235
tree=1, node=318, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=319, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=5, feature=15, thr=  1.50, gain=0.383729
tree=1, node=10, feature=6, thr= 72.50, gain=0.381235
tree=1, node=20, feature=3, thr= 98.50, gain=0.239629
tree=1, node=40, feature=6, thr= 55.50, gain=0.060567
tree=1, node=80, feature=2, thr= 73.50, gain=0.262813
tree=1, node=160, feature=7, thr= 63.50, gain=0.679884
tree=1, node=320, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=321, feature=14, thr=  2.00, gain=0.028034
tree=1, node=642, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=643, feature=2, thr= 42.50, gain=0.017781
tree=1, node=1286, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=1287, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=161, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=81, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=41, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=21, feature=5, thr= 58.50, gain=0.662691
tree=1, node=42, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=43, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=11, feature=0, thr= 20.50, gain=0.564588
tree=1, node=22, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=23, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=3, feature=5, thr= 47.50, gain=0.507976
tree=1, node=6, feature=9, thr= 52.50, gain=0.124920
tree=1, node=12, feature=10, thr= 31.50, gain=0.810701
tree=1, node=24, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=25, feature=12, thr= 93.50, gain=0.284869
tree=1, node=50, feature=6, thr= 17.50, gain=0.139598
tree=1, node=100, feature=0, thr= 45.50, gain=0.371028
tree=1, node=200, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=201, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=101, feature=12, thr= 59.50, gain=0.065103
tree=1, node=202, feature=7, thr=  6.50, gain=0.050832
tree=1, node=404, feature=12, thr= 44.50, gain=0.019529
tree=1, node=808, feature=-1, thr= -1.00, gain=0.000000
```

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tree=1, node=809, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=405, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=203, feature=9, thr= 31.50, gain=0.190105
tree=1, node=406, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=407, feature=-1, thr= -1.00, gain=0.000000
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tree=1, node=102, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=103, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=13, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=7, feature=10, thr= 62.50, gain=0.308820
tree=1, node=14, feature=0, thr= 34.50, gain=0.675180
tree=1, node=28, feature=13, thr= 77.00, gain=0.467518
tree=1, node=56, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=57, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=29, feature=12, thr= 45.50, gain=0.106672
tree=1, node=58, feature=2, thr= 23.50, gain=0.320876
tree=1, node=116, feature=5, thr= 61.50, gain=0.181579
tree=1, node=232, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=233, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=117, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=59, feature=11, thr= 14.50, gain=0.327728
tree=1, node=118, feature=2, thr= 51.00, gain=0.502905
tree=1, node=236, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=237, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=119, feature=4, thr= 46.50, gain=0.143960
tree=1, node=238, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=239, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=15, feature=10, thr= 87.50, gain=0.089317
tree=1, node=30, feature=8, thr= 59.50, gain=0.599503
tree=1, node=60, feature=7, thr= 35.50, gain=0.563132
tree=1, node=120, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=121, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=61, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=31, feature=10, thr= 94.50, gain=0.035275
tree=1, node=62, feature=-1, thr= -1.00, gain=0.000000
tree=1, node=63, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=1, feature=9, thr= 29.50, gain=0.400780
tree=2, node=2, feature=9, thr=  6.50, gain=0.217871
tree=2, node=4, feature=12, thr= 48.50, gain=0.251159
tree=2, node=8, feature=7, thr= 30.50, gain=0.452176
tree=2, node=16, feature=14, thr= 47.50, gain=0.893289
tree=2, node=32, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=33, feature=11, thr= 40.50, gain=0.784200
tree=2, node=66, feature=13, thr= 51.50, gain=0.489181
tree=2, node=132, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=133, feature=-1, thr= -1.00, gain=0.000000
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tree=2, node=67, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=17, feature=15, thr= 59.00, gain=0.727554
tree=2, node=34, feature=2, thr= 57.50, gain=0.101869
tree=2, node=68, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=69, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=35, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=9, feature=0, thr= 47.50, gain=0.595054
tree=2, node=18, feature=12, thr= 68.50, gain=0.330563
tree=2, node=36, feature=5, thr= 57.50, gain=0.150791
tree=2, node=72, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=73, feature=14, thr= 88.50, gain=0.181904
tree=2, node=146, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=147, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=37, feature=2, thr= 25.50, gain=0.635711
tree=2, node=74, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=75, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=19, feature=5, thr= 44.50, gain=0.089978
tree=2, node=38, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=39, feature=6, thr= 33.00, gain=0.613815
tree=2, node=78, feature=3, thr= 97.50, gain=0.071720
tree=2, node=156, feature=0, thr= 96.50, gain=0.045475
tree=2, node=312, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=313, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=157, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=79, feature=8, thr= 29.50, gain=0.198132
tree=2, node=158, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=159, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=5, feature=9, thr= 19.50, gain=0.069424
tree=2, node=10, feature=11, thr= 33.50, gain=0.748171
tree=2, node=20, feature=5, thr= 79.50, gain=0.349236
tree=2, node=40, feature=12, thr= 35.50, gain=0.318689
tree=2, node=80, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=81, feature=7, thr= 40.50, gain=0.083445
tree=2, node=162, feature=13, thr= 16.50, gain=0.418738
tree=2, node=324, feature=12, thr= 61.50, gain=0.028082
tree=2, node=648, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=649, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=325, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=163, feature=5, thr= 71.50, gain=0.207548
tree=2, node=326, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=327, feature=10, thr= 23.50, gain=0.618230
tree=2, node=654, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=655, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=41, feature=3, thr= 94.50, gain=0.182277
tree=2, node=82, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=83, feature=13, thr= 20.50, gain=0.903872
```

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tree=2, node=166, feature=12, thr= 47.50, gain=0.221413
tree=2, node=332, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=333, feature=2, thr= 40.50, gain=0.126053
tree=2, node=666, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=667, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=167, feature=5, thr= 88.50, gain=0.071690
tree=2, node=334, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=335, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=21, feature=9, thr= 10.50, gain=0.056256
tree=2, node=42, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=43, feature=9, thr= 13.50, gain=0.027330
tree=2, node=86, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=87, feature=11, thr= 58.50, gain=0.392568
tree=2, node=174, feature=9, thr= 16.50, gain=0.079299
tree=2, node=348, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=349, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=175, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=11, feature=14, thr= 50.50, gain=0.788604
tree=2, node=22, feature=10, thr= 84.50, gain=0.790243
tree=2, node=44, feature=1, thr= 96.50, gain=0.211018
tree=2, node=88, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=89, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=45, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=23, feature=7, thr= 40.50, gain=0.754325
tree=2, node=46, feature=5, thr= 44.50, gain=0.427417
tree=2, node=92, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=93, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=47, feature=10, thr= 33.50, gain=0.363363
tree=2, node=94, feature=4, thr= 99.50, gain=0.262523
tree=2, node=188, feature=12, thr= 35.50, gain=0.473920
tree=2, node=376, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=377, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=189, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=95, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=3, feature=1, thr= 99.50, gain=0.400807
tree=2, node=6, feature=13, thr= 42.50, gain=0.515047
tree=2, node=12, feature=6, thr= 74.50, gain=0.367293
tree=2, node=24, feature=13, thr= 18.50, gain=0.352795
tree=2, node=48, feature=11, thr= 26.50, gain=0.309581
tree=2, node=96, feature=14, thr= 63.50, gain=0.608686
tree=2, node=192, feature=14, thr=  0.50, gain=0.114868
tree=2, node=384, feature=1, thr= 91.50, gain=0.140217
tree=2, node=768, feature=7, thr= 76.50, gain=0.226518
tree=2, node=1536, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=1537, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=769, feature=6, thr= 55.50, gain=0.429503
```

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tree=2, node=1538, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=1539, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=385, feature=10, thr= 88.50, gain=0.522187
tree=2, node=770, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=771, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=193, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=97, feature=1, thr= 76.50, gain=0.237348
tree=2, node=194, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=195, feature=9, thr= 62.50, gain=0.475304
tree=2, node=390, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=391, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=49, feature=3, thr= 94.50, gain=0.205759
tree=2, node=98, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=99, feature=1, thr= 87.50, gain=0.283496
tree=2, node=198, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=199, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=25, feature=8, thr= 66.50, gain=0.190546
tree=2, node=50, feature=1, thr= 68.50, gain=0.345480
tree=2, node=100, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=101, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=51, feature=13, thr= 15.50, gain=0.434086
tree=2, node=102, feature=1, thr= 66.50, gain=0.435255
tree=2, node=204, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=205, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=103, feature=4, thr= 40.50, gain=0.167264
tree=2, node=206, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=207, feature=5, thr= 91.50, gain=0.171023
tree=2, node=414, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=415, feature=3, thr= 89.00, gain=0.864994
tree=2, node=830, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=831, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=13, feature=11, thr= 75.50, gain=0.306623
tree=2, node=26, feature=14, thr= 72.50, gain=0.765130
tree=2, node=52, feature=1, thr= 84.50, gain=0.030765
tree=2, node=104, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=105, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=53, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=27, feature=8, thr= 77.50, gain=0.714830
tree=2, node=54, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=55, feature=0, thr=  0.50, gain=0.201759
tree=2, node=110, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=111, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=7, feature=2, thr= 53.50, gain=0.191745
tree=2, node=14, feature=9, thr= 46.50, gain=0.095927
tree=2, node=28, feature=8, thr= 37.00, gain=0.298935
tree=2, node=56, feature=-1, thr= -1.00, gain=0.000000
```

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tree=2, node=57, feature=6, thr= 52.50, gain=0.227577
tree=2, node=114, feature=9, thr= 37.50, gain=0.025712
tree=2, node=228, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=229, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=115, feature=12, thr= 51.50, gain=0.560664
tree=2, node=230, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=231, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=29, feature=15, thr=  0.50, gain=0.337468
tree=2, node=58, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=59, feature=-1, thr= -1.00, gain=0.000000
tree=2, node=15, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=1, feature=13, thr= 52.50, gain=0.549898
tree=3, node=2, feature=7, thr= 48.50, gain=0.481835
tree=3, node=4, feature=10, thr= 49.50, gain=0.695499
tree=3, node=8, feature=6, thr= 22.50, gain=0.241892
tree=3, node=16, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=17, feature=11, thr= 24.50, gain=0.115292
tree=3, node=34, feature=1, thr= 87.50, gain=0.300588
tree=3, node=68, feature=13, thr= 25.00, gain=0.723559
tree=3, node=136, feature=0, thr= 13.50, gain=0.034531
tree=3, node=272, feature=5, thr= 79.50, gain=0.127354
tree=3, node=544, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=545, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=273, feature=11, thr= 15.50, gain=0.049975
tree=3, node=546, feature=12, thr= 50.50, gain=0.074223
tree=3, node=1092, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=1093, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=547, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=137, feature=6, thr= 51.50, gain=0.247578
tree=3, node=274, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=275, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=69, feature=10, thr=  1.50, gain=0.126699
tree=3, node=138, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=139, feature=11, thr=  1.50, gain=0.010545
tree=3, node=278, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=279, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=35, feature=0, thr=  4.50, gain=0.245028
tree=3, node=70, feature=2, thr= 35.50, gain=0.065172
tree=3, node=140, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=141, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=71, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=9, feature=1, thr= 99.50, gain=0.254640
tree=3, node=18, feature=7, thr= 42.50, gain=0.253436
tree=3, node=36, feature=7, thr= 35.50, gain=0.122429
tree=3, node=72, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=73, feature=4, thr= 63.50, gain=0.945413
```

```
tree=3, node=146, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=147, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=37, feature=13, thr= 13.00, gain=0.952792
tree=3, node=74, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=75, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=19, feature=2, thr= 42.50, gain=0.220996
tree=3, node=38, feature=14, thr= 38.50, gain=0.514399
tree=3, node=76, feature=7, thr= 30.50, gain=0.598055
tree=3, node=152, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=153, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=77, feature=14, thr= 47.50, gain=0.052917
tree=3, node=154, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=155, feature=6, thr=  1.50, gain=0.012795
tree=3, node=310, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=311, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=39, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=5, feature=11, thr= 39.50, gain=0.395604
tree=3, node=10, feature=6, thr= 49.50, gain=0.219383
tree=3, node=20, feature=1, thr= 67.50, gain=0.233459
tree=3, node=40, feature=15, thr= 12.50, gain=0.810842
tree=3, node=80, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=81, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=41, feature=1, thr= 89.50, gain=0.199557
tree=3, node=82, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=83, feature=12, thr= 71.50, gain=0.397467
tree=3, node=166, feature=10, thr= 47.50, gain=0.776890
tree=3, node=332, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=333, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=167, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=21, feature=14, thr= 45.50, gain=0.770678
tree=3, node=42, feature=13, thr= 15.50, gain=0.115870
tree=3, node=84, feature=5, thr= 70.50, gain=0.142560
tree=3, node=168, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=169, feature=3, thr= 92.50, gain=0.230576
tree=3, node=338, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=339, feature=5, thr= 93.50, gain=0.075265
tree=3, node=678, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=679, feature=0, thr= 30.00, gain=0.259698
tree=3, node=1358, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=1359, feature=-1, thr= -1.00, gain=0.000000
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tree=3, node=43, feature=2, thr= 39.50, gain=0.113662
tree=3, node=86, feature=10, thr= 38.50, gain=0.257164
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tree=3, node=173, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=87, feature=11, thr=  0.50, gain=0.485796
```

```
tree=3, node=174, feature=3, thr= 94.50, gain=0.211422
tree=3, node=348, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=349, feature=2, thr= 63.50, gain=0.210093
tree=3, node=698, feature=6, thr= 82.50, gain=0.099030
tree=3, node=1396, feature=-1, thr= -1.00, gain=0.000000
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```

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tree=3, node=383, feature=8, thr= 98.50, gain=0.237652
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tree=3, node=24, feature=10, thr= 34.00, gain=0.274910
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tree=3, node=55, feature=14, thr= 55.50, gain=0.699382
tree=3, node=110, feature=-1, thr= -1.00, gain=0.000000
```

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tree=3, node=111, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=7, feature=6, thr= 42.50, gain=0.258088
tree=3, node=14, feature=-1, thr= -1.00, gain=0.000000
tree=3, node=15, feature=-1, thr= -1.00, gain=0.000000
...................Model Training Complete.....................
classification accuracy=0.8313
```

Task 2:

Part a:

Initial Entropy at node A is defined as:

$$S = H\left(\frac{-k1}{k}, \frac{-k2}{k}\right) = -\frac{k1}{k}\log_2\left(\frac{k1}{k}\right) - \frac{k2}{k}\log_2\left(\frac{k2}{k}\right)$$

Substituting the values, we have:

$$S = -\frac{80}{100}\log_2\left(\frac{80}{100}\right) - \frac{20}{100}\log_2\left(\frac{20}{100}\right) = 0.7219$$

Part b:

Calculating weekend entropy:

$$S = H\left(\frac{-k1}{k}, \frac{-k2}{k}\right) = -\frac{k1}{k}\log_2\left(\frac{k1}{k}\right) - \frac{k2}{k}\log_2\left(\frac{k2}{k}\right)$$

Substituting the values, we have:

$$S = -\frac{20}{35}\log_2\left(\frac{20}{35}\right) - \frac{15}{35}\log_2\left(\frac{15}{35}\right) = 0.985$$

Calculating not-a-weekend entropy:

$$S = H\left(\frac{-k1}{k}, \frac{-k2}{k}\right) = -\frac{k1}{k}\log_2\left(\frac{k1}{k}\right) - \frac{k2}{k}\log_2\left(\frac{k2}{k}\right)$$

Substituting the values, we have:

$$S = -\frac{60}{65}\log_2\left(\frac{60}{65}\right) - \frac{5}{65}\log_2\left(\frac{5}{65}\right) = 0.391$$

Calculating Information Gain:

$$I(A) = H(A) - (\frac{35}{100} * 0.985) - (\frac{65}{100} * 0.391)$$

$$I(A) = 0.7219 - (\frac{35}{100} * 0.985) - (\frac{65}{100} * 0.391) = 0.123$$

Part c:

There will be no information gain at node E since the exact same test has been used before to separate the data. This means that all the examples at node E will already be of the same type, which will give us an information gain of 0.

Part d:

Since it is not a weekend (Tuesday), we check if it is rainy or not.
Since it is raining, the hungry patron WILL WAIT
The test case ends up on leaf node F.
The decision tree output will be:
Node A: Weekend? → No (it's Tuesday)
Node C: Raining? → Yes
Node F: Answer: "will wait"

Part e:

Since it is a weekend (Saturday), we check if the patron is hungry or not.
Since the patron is not hungry, we check if it is a weekend or not.
Since it is a weekend, the patron WILL NOT WAIT.
The test case ends up on leaf node H.
The decision tree output will be:
Node A: Weekend (Saturday) → left branch
Node B: Not hungry → right branch
Node E: Weekend → left branch
Node H: "will not wait"

Task 3:

Calculating the initial entropy:

$$S = -\frac{5}{10}\log_2\left(\frac{5}{10}\right) - \frac{5}{10}\log_2\left(\frac{5}{10}\right) = 1$$

Case 1: A
A = 1 ; X = 3 and Y = 0

$$H(A1) = -\frac{3}{3}\log_2\left(\frac{3}{3}\right) - \frac{0}{3}\log_2\left(\frac{0}{3}\right) = 0$$

A = 2 ; X = 1 and Y = 3

$$H(A2) = -\frac{1}{4}\log_2\left(\frac{1}{4}\right) - \frac{3}{4}\log_2\left(\frac{3}{4}\right) = 0.8113$$

A = 3 ; X = 1 and Y = 2

$$H(A3) = -\frac{1}{3}\log_2\left(\frac{1}{3}\right) - \frac{2}{3}\log_2\left(\frac{2}{3}\right) = 0.9183$$

$$I(A) = 1 - (\frac{3}{10} * 0) - (\frac{4}{10} * 0.8113) - (\frac{3}{10} * 0.9183) = 0.3999$$

Case 2: B
B = 1 ; X = 1 and Y = 3

$$H(B1) = -\frac{1}{4}\log_2\left(\frac{1}{4}\right) - \frac{3}{4}\log_2\left(\frac{3}{4}\right) = 0.8113$$

B = 2 ; X = 3 and Y = 1

$$H(B2) = -\frac{3}{4}\log_2\left(\frac{3}{4}\right) - \frac{1}{4}\log_2\left(\frac{1}{4}\right) = 0.8113$$

B = 3 ; X = 1 and Y = 1

$$H(B3) = -\frac{1}{2}\log_2\left(\frac{1}{2}\right) - \frac{1}{2}\log_2\left(\frac{1}{2}\right) = 1$$

$$I(B) = 1 - (\frac{4}{10} * 0.8113) - (\frac{4}{10} * 0.8113) - (\frac{2}{10} * 1) = 0.1510$$

Case 3: C
C = 1 ; X = 1 and Y = 4

$$H(C1) = -\frac{1}{5}\log_2\left(\frac{1}{5}\right) - \frac{4}{5}\log_2\left(\frac{4}{5}\right) = 0.7219$$

C = 2 ; X = 3 and Y = 1

$$H(C2) = -\frac{3}{4}\log_2\left(\frac{3}{4}\right) - \frac{1}{4}\log_2\left(\frac{1}{4}\right) = 0.8113$$

C = 3 ; X = 1 and Y = 0

$$H(C3) = -\frac{1}{1}\log_2\left(\frac{1}{1}\right) - \frac{0}{1}\log_2\left(\frac{0}{1}\right) = 0$$

$$I(C) = 1 - (\frac{5}{10} * 0.7219) - (\frac{4}{10} * 0.8113) - (\frac{1}{10} * 0) = 0.3145$$

Since I(A) is greater than I(B) and I(C), A has the highest information gain.

Task 4:

Part a:

Highest possible entropy:

Occurs with uniform distribution across classes Each class has 250 samples

$$H_{max} = -\sum_{i=1}^{4} \frac{250}{1000} \log_2(\frac{250}{1000}) = -4 \cdot 0.25 \log_2(0.25) = 2bits$$

Lowest possible entropy:

Occurs when all samples are in one class

$$H_{min} = -1 \log_2(1) = 0bits$$

Part b:

Maximum Information Gain:

Parent has maximum entropy (2 bits) Children have minimum entropy (0 bits)

$$IG_{max} = H_{parent} - H_{children} = 2 - 0 = 2bits$$

Minimum Information Gain:

Split provides no information (children have same entropy as parent)

$$IG_{min} = 0bits$$

Task 5:

Given:

- Binary classifier for game outcomes: {win, loss}
- Current accuracy = 28%
- Target accuracy should be greater than 60%

Key Observation:
28% accuracy is significantly below random guessing (50%) for a binary classifier. This suggests a systematic error in prediction.

Solution Strategy:
Invert all predictions of the original classifier:

$$f_{new}(x) = \neg f_{original}(x)$$

Proof of Effectiveness:

- Original error rate = 72% (100% - 28%)

- By inverting predictions:

$$new accuracy = original error rate = 72\%$$

- $72\% > 60\%$ (target accuracy)

Conclusion:
Yes, we can guarantee better than 60% accuracy by simply inverting the predictions of the current classifier, which will achieve 72% accuracy. This works because the original classifier is performing significantly worse than random chance in a consistent manner.