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Assignment 5 Written Task

TASK1

Output for Command `python3 decision_tree.py pendigits_training.txt pendigits_test.txt optimized 50`

```
tree= 1, node= 1, feature=16, thr= 21.57, gain=0.621424
tree= 1, node= 2, feature= 5, thr= 41.18, gain=0.587628
tree= 1, node= 3, feature=14, thr= 58.82, gain=0.697235
tree= 1, node= 4, feature=10, thr= 15.69, gain=0.670083
tree= 1, node= 5, feature=11, thr= 39.22, gain=0.629044
tree= 1, node= 6, feature= 1, thr= 35.29, gain=0.712500
tree= 1, node= 7, feature= 9, thr= 56.86, gain=0.814218
tree= 1, node= 8, feature=15, thr= 60.78, gain=0.475710
tree= 1, node= 9, feature= 6, thr= 64.71, gain=0.620325
tree= 1, node=10, feature=15, thr= 37.25, gain=0.224713
tree= 1, node=11, feature= 4, thr= 90.20, gain=0.686759
tree= 1, node=12, feature=15, thr= 37.25, gain=0.281171
tree= 1, node=13, feature=11, thr= 29.41, gain=0.584898
tree= 1, node=14, feature=15, thr= 96.08, gain=0.737506
tree= 1, node=15, feature= 8, thr= 24.33, gain=0.205385
tree= 1, node=16, feature= 2, thr= 73.53, gain=0.027989
tree= 1, node=17, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=18, feature=16, thr=  0.41, gain=0.188928
tree= 1, node=19, feature=10, thr= 60.47, gain=0.530651
tree= 1, node=20, feature=13, thr= 30.06, gain=0.640257
tree= 1, node=21, feature= 9, thr= 34.59, gain=0.140904
tree= 1, node=22, feature= 7, thr= 72.55, gain=0.509615
tree= 1, node=23, feature= 8, thr= 77.10, gain=0.409412
tree= 1, node=24, feature= 2, thr= 84.51, gain=0.550957
tree= 1, node=25, feature=14, thr= 14.78, gain=0.131381
tree= 1, node=26, feature=16, thr= 31.18, gain=0.222560
tree= 1, node=27, feature=10, thr= 19.61, gain=0.464511
tree= 1, node=28, feature=12, thr= 31.67, gain=0.157508
tree= 1, node=29, feature=14, thr= 71.06, gain=0.344859
tree= 1, node=30, feature= 3, thr= 54.90, gain=0.092930
tree= 1, node=31, feature=10, thr= 58.82, gain=0.918296
tree= 1, node=32, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=33, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=34, feature= 8, thr= 66.47, gain=0.110097
tree= 1, node=35, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=36, feature=15, thr= 25.49, gain=0.773333
tree= 1, node=37, feature= 1, thr= 39.22, gain=0.203813
tree= 1, node=38, feature= 4, thr= 96.71, gain=0.374672
tree= 1, node=39, feature=-1, thr= -1.00, gain=0.000000
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tree= 1, node= 40, feature=10, thr= 1.43, gain=0.077936
tree= 1, node= 41, feature= 7, thr= 68.14, gain=0.274080
tree= 1, node= 42, feature=15, thr= 96.08, gain=0.341335
tree= 1, node= 43, feature= 2, thr= 82.35, gain=0.324193
tree= 1, node= 44, feature= 3, thr= 88.59, gain=0.253482
tree= 1, node= 45, feature= 6, thr= 89.29, gain=0.811518
tree= 1, node= 46, feature= 9, thr= 76.47, gain=0.650022
tree= 1, node= 47, feature= 7, thr= 50.47, gain=0.757526
tree= 1, node= 48, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 49, feature= 4, thr= 87.45, gain=0.051386
tree= 1, node= 50, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 51, feature= 1, thr= 53.57, gain=0.129949
tree= 1, node= 52, feature=16, thr= 67.29, gain=0.265884
tree= 1, node= 53, feature=11, thr= 67.06, gain=0.773029
tree= 1, node= 54, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 55, feature=13, thr= 21.57, gain=0.159034
tree= 1, node= 56, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 57, feature= 6, thr= 54.41, gain=0.006884
tree= 1, node= 58, feature= 7, thr= 96.08, gain=0.024998
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tree= 1, node= 62, feature= 6, thr= 13.35, gain=0.035341
tree= 1, node= 63, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 64, feature= 8, thr= 71.86, gain=0.496889
tree= 1, node= 65, feature=11, thr= 60.78, gain=0.864204
tree= 1, node= 66, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 67, feature= 2, thr= 92.47, gain=0.078528
tree= 1, node= 68, feature= 6, thr= 68.63, gain=0.135036
tree= 1, node= 69, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 70, feature= 9, thr= 18.67, gain=0.368566
tree= 1, node= 71, feature= 8, thr= 73.02, gain=0.050120
tree= 1, node= 72, feature=13, thr= 55.47, gain=0.287642
tree= 1, node= 73, feature= 9, thr= 49.82, gain=0.208356
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tree= 1, node= 75, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 76, feature= 6, thr= 15.69, gain=0.106446
tree= 1, node= 77, feature=-1, thr= -1.00, gain=0.000000
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tree= 1, node= 79, feature= 6, thr= 84.31, gain=0.901825
tree= 1, node= 80, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 81, feature= 7, thr= 70.59, gain=0.988057
tree= 1, node= 82, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 83, feature=-1, thr= -1.00, gain=0.000000
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tree= 1, node= 87, feature= 9, thr= 1.96, gain=0.027154

tree= 1, node= 88, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 89, feature=15, thr= 1.96, gain=0.057144
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tree= 1, node= 93, feature=-1, thr= -1.00, gain=0.000000
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tree= 1, node= 96, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 97, feature= 7, thr= 45.33, gain=0.097300
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tree= 1, node=104, feature=14, thr= 5.10, gain=0.465185
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tree= 1, node=118, feature= 1, thr= 73.33, gain=0.054012
tree= 1, node=119, feature=12, thr= 9.06, gain=0.541116
tree= 1, node=120, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=121, feature= 8, thr= 67.06, gain=0.321696
tree= 1, node=122, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=123, feature= 1, thr= 60.78, gain=0.098830
tree= 1, node=124, feature=10, thr= 18.55, gain=0.134335
tree= 1, node=125, feature=-1, thr= -1.00, gain=0.000000
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tree= 1, node=127, feature= 2, thr= 79.29, gain=0.678954
tree= 1, node=128, feature= 5, thr= 48.04, gain=0.291818
tree= 1, node=129, feature=12, thr= 39.69, gain=0.517478
tree= 1, node=130, feature=-1, thr= -1.00, gain=0.000000
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tree= 1, node=135, feature=-1, thr= -1.00, gain=0.000000

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tree= 1, node=137, feature=-1, thr= -1.00, gain=0.000000
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tree= 1, node=140, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=141, feature=10, thr= 88.47, gain=0.008575
tree= 1, node=142, feature= 7, thr= 67.45, gain=0.250919
tree= 1, node=143, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=144, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=145, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=146, feature=-1, thr= -1.00, gain=0.000000
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tree= 1, node=152, feature= 2, thr= 89.59, gain=0.025926
tree= 1, node=153, feature=-1, thr= -1.00, gain=0.000000
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=156, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=157, feature= 4, thr= 89.02, gain=0.028237
tree= 1, node=158, feature= 9, thr= 24.51, gain=0.021367
tree= 1, node=159, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=160, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=161, feature=15, thr= 52.94, gain=0.111623
tree= 1, node=162, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=163, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=164, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=165, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=166, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=167, feature= 3, thr= 45.71, gain=0.103275
tree= 1, node=168, feature= 8, thr= 17.69, gain=0.008314
tree= 1, node=169, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=170, feature= 2, thr= 81.37, gain=0.056120
tree= 1, node=171, feature=-1, thr= -1.00, gain=0.000000
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tree= 1, node=173, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=174, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=175, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=176, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=177, feature=16, thr= 9.12, gain=0.021405
tree= 1, node=178, feature= 7, thr= 21.57, gain=0.053910
tree= 1, node=179, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=180, feature= 2, thr= 66.67, gain=0.077022
tree= 1, node=181, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=182, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=183, feature=-1, thr= -1.00, gain=0.000000

```
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=186, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=187, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=188, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=189, feature= 4, thr= 99.12, gain=0.041635
tree= 1, node=190, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=191, feature= 3, thr= 41.47, gain=0.067329
tree= 1, node=192, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=193, feature= 3, thr= 86.33, gain=0.018695
tree= 1, node=194, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=195, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=196, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=197, feature=-1, thr= -1.00, gain=0.000000
```

classification accuracy=0.8382

Output for Command python3 decision_tree.py pendigits_training.txt pendigits_test.txt randomized 50

```
tree= 1, node= 1, feature=11, thr= 56.86, gain=0.474440
tree= 1, node= 2, feature=14, thr= 27.45, gain=0.676611
tree= 1, node= 3, feature=12, thr= 37.25, gain=0.522972
tree= 1, node= 4, feature= 9, thr= 35.29, gain=0.317141
tree= 1, node= 5, feature=14, thr= 81.65, gain=0.710664
tree= 1, node= 6, feature= 3, thr= 64.71, gain=0.104459
tree= 1, node= 7, feature=14, thr= 60.78, gain=0.879792
tree= 1, node= 8, feature=13, thr= 41.18, gain=0.179793
tree= 1, node= 9, feature=15, thr= 60.78, gain=0.211328
tree= 1, node=10, feature=10, thr= 54.90, gain=0.334623
tree= 1, node=11, feature= 3, thr= 61.25, gain=0.026071
tree= 1, node=12, feature=14, thr= 15.88, gain=0.897130
tree= 1, node=13, feature= 4, thr= 99.02, gain=0.254690
tree= 1, node=14, feature= 8, thr= 62.75, gain=0.793630
tree= 1, node=15, feature= 1, thr= 1.96, gain=0.073895
tree= 1, node=16, feature= 6, thr= 88.53, gain=0.491755
tree= 1, node=17, feature=14, thr= 15.35, gain=0.173300
tree= 1, node=18, feature=10, thr= 58.16, gain=0.282919
tree= 1, node=19, feature= 1, thr= 6.67, gain=0.129717
tree= 1, node=20, feature= 9, thr= 11.76, gain=0.114607
tree= 1, node=21, feature= 9, thr= 45.10, gain=0.300426
tree= 1, node=22, feature= 9, thr= 50.98, gain=0.066859
tree= 1, node=23, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=24, feature= 4, thr= 90.47, gain=0.345011
tree= 1, node=25, feature= 3, thr= 30.12, gain=0.088896
tree= 1, node=26, feature= 8, thr= 46.67, gain=0.866824
tree= 1, node=27, feature=16, thr= 28.55, gain=0.242354
tree= 1, node=28, feature=16, thr= 1.02, gain=0.054422
```

tree= 1, node= 29, feature= 8, thr= 96.37, gain=0.200378
tree= 1, node= 30, feature=10, thr= 70.59, gain=0.584395
tree= 1, node= 31, feature=13, thr= 92.39, gain=0.222068
tree= 1, node= 32, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 33, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 34, feature=13, thr= 56.02, gain=0.066311
tree= 1, node= 35, feature= 5, thr= 52.35, gain=0.657353
tree= 1, node= 36, feature= 1, thr= 25.49, gain=0.643920
tree= 1, node= 37, feature= 5, thr= 86.27, gain=0.186259
tree= 1, node= 38, feature= 2, thr= 71.53, gain=0.447659
tree= 1, node= 39, feature= 8, thr= 54.06, gain=0.043532
tree= 1, node= 40, feature= 1, thr= 39.22, gain=0.342787
tree= 1, node= 41, feature= 8, thr= 31.37, gain=0.025451
tree= 1, node= 42, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 43, feature= 4, thr= 58.82, gain=0.547448
tree= 1, node= 44, feature=10, thr= 42.71, gain=0.015853
tree= 1, node= 45, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 46, feature= 7, thr= 54.90, gain=0.375446
tree= 1, node= 47, feature= 1, thr= 60.78, gain=0.586413
tree= 1, node= 48, feature= 5, thr= 21.57, gain=0.291818
tree= 1, node= 49, feature=12, thr= 28.29, gain=0.135687
tree= 1, node= 50, feature=11, thr= 92.41, gain=0.165928
tree= 1, node= 51, feature=16, thr= 26.47, gain=0.444196
tree= 1, node= 52, feature= 6, thr= 88.75, gain=0.436390
tree= 1, node= 53, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 54, feature= 4, thr= 98.04, gain=0.215096
tree= 1, node= 55, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 56, feature=13, thr= 60.29, gain=0.100184
tree= 1, node= 57, feature= 3, thr= 43.14, gain=0.093934
tree= 1, node= 58, feature= 1, thr= 0.02, gain=0.078982
tree= 1, node= 59, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 60, feature=14, thr= 99.24, gain=0.056230
tree= 1, node= 61, feature=15, thr= 38.59, gain=0.307649
tree= 1, node= 62, feature=10, thr= 5.49, gain=0.117222
tree= 1, node= 63, feature= 9, thr= 9.61, gain=0.076209
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tree= 1, node= 65, feature= 4, thr= 75.55, gain=0.450067
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tree= 1, node= 67, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 68, feature=15, thr= 24.29, gain=0.216122
tree= 1, node= 69, feature=11, thr= 43.06, gain=0.055492
tree= 1, node= 70, feature=16, thr= 11.18, gain=0.061566
tree= 1, node= 71, feature= 5, thr= 90.20, gain=0.170525
tree= 1, node= 72, feature=16, thr= 23.73, gain=0.315997
tree= 1, node= 73, feature=11, thr= 12.08, gain=0.175703
tree= 1, node= 74, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 75, feature= 9, thr= 4.10, gain=0.030987
tree= 1, node= 76, feature=15, thr= 89.41, gain=0.355969

tree= 1, node= 77, feature= 8, thr= 70.67, gain=0.020784
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= 80, feature= 7, thr= 76.47, gain=0.050717
tree= 1, node= 81, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 82, feature=12, thr= 11.61, gain=0.392147
tree= 1, node= 83, feature= 1, thr= 29.41, gain=0.788985
tree= 1, node= 84, feature= 6, thr= 82.35, gain=0.084236
tree= 1, node= 85, feature= 4, thr= 93.12, gain=0.028253
tree= 1, node= 86, feature= 4, thr= 68.65, gain=0.059114
tree= 1, node= 87, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 88, feature=12, thr= 0.55, gain=0.107887
tree= 1, node= 89, feature= 3, thr= 52.35, gain=0.255466
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= 92, feature=13, thr= 16.47, gain=0.200665
tree= 1, node= 93, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 94, feature=12, thr= 21.04, gain=0.180254
tree= 1, node= 95, feature= 2, thr= 74.76, gain=0.427659
tree= 1, node= 96, feature=16, thr= 0.00, gain=0.000000
tree= 1, node= 97, feature=15, thr= 23.53, gain=0.235221
tree= 1, node= 98, feature= 6, thr= 88.78, gain=0.403229
tree= 1, node= 99, feature=16, thr= 1.35, gain=0.009978
tree= 1, node=100, feature= 5, thr= 92.16, gain=0.237181
tree= 1, node=101, feature= 4, thr= 42.20, gain=0.044037
tree= 1, node=102, feature=-1, thr= -1.00, gain=0.000000
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tree= 1, node=104, feature=14, thr= 81.12, gain=0.005803
tree= 1, node=105, feature= 9, thr= 66.67, gain=0.588622
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tree= 1, node=107, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=108, feature=16, thr= 1.06, gain=0.167358
tree= 1, node=109, feature=11, thr= 18.71, gain=0.130995
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tree= 1, node=423, feature= 3, thr= 25.71, gain=0.462506
tree= 1, node=424, feature=10, thr= 12.08, gain=0.172037
tree= 1, node=425, feature= 5, thr= 39.22, gain=0.086343
tree= 1, node=426, feature= 7, thr= 67.06, gain=0.174455
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tree= 1, node=440, feature= 7, thr= 25.41, gain=0.096945
tree= 1, node=441, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=442, feature=15, thr= 87.37, gain=0.035323
tree= 1, node=443, feature=-1, thr= -1.00, gain=0.000000
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tree= 1, node=460, feature=-1, thr= -1.00, gain=0.000000

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tree= 1, node=461, feature=11, thr= 1.10, gain=0.038574
tree= 1, node=462, feature= 7, thr= 98.27, gain=0.075603
tree= 1, node=463, feature=14, thr= 32.12, gain=0.104559
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tree= 1, node=472, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=473, feature=-1, thr= -1.00, gain=0.000000
classification accuracy=0.7140
```

Output for Command python3 decision_tree.py pendigits_training.txt pendigits_test.txt forest3 50

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tree= 1, node= 1, feature=12, thr= 35.29, gain=0.466267
tree= 1, node= 2, feature= 4, thr= 96.53, gain=0.349658
tree= 1, node= 3, feature= 2, thr= 98.04, gain=0.408999
tree= 1, node= 4, feature= 6, thr= 71.06, gain=0.597131
tree= 1, node= 5, feature=10, thr= 33.35, gain=0.662826
tree= 1, node= 6, feature=15, thr= 98.04, gain=0.399265
tree= 1, node= 7, feature=14, thr= 60.78, gain=0.819294
tree= 1, node= 8, feature=15, thr= 47.06, gain=0.469430
tree= 1, node= 9, feature=10, thr= 37.43, gain=0.234399
tree= 1, node=10, feature=11, thr= 35.29, gain=0.307247
tree= 1, node=11, feature=16, thr=  6.43, gain=0.089299
tree= 1, node=12, feature= 8, thr= 47.06, gain=0.881814
tree= 1, node=13, feature= 2, thr= 67.25, gain=0.292814
tree= 1, node=14, feature= 5, thr= 35.29, gain=0.306374
tree= 1, node=15, feature= 6, thr= 34.82, gain=0.299387
tree= 1, node=16, feature= 6, thr= 61.31, gain=0.111700
tree= 1, node=17, feature= 3, thr= 52.94, gain=0.456562
tree= 1, node=18, feature= 4, thr= 87.53, gain=0.260793
tree= 1, node=19, feature= 5, thr= 45.10, gain=0.249250
tree= 1, node=20, feature= 1, thr= 54.90, gain=0.409945
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tree= 1, node=22, feature= 3, thr= 86.41, gain=0.157356
tree= 1, node=23, feature= 2, thr= 88.39, gain=0.250532
tree= 1, node=24, feature=12, thr= 78.67, gain=0.191063
tree= 1, node=25, feature= 5, thr= 35.29, gain=0.274616
tree= 1, node=26, feature=16, thr=  1.96, gain=0.892121
tree= 1, node=27, feature= 8, thr= 15.69, gain=0.316062
tree= 1, node=28, feature=14, thr= 49.41, gain=0.031802
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tree= 1, node= 32, feature= 6, thr= 49.47, gain=0.033296
tree= 1, node= 33, feature= 5, thr= 47.06, gain=0.530224
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tree= 1, node= 36, feature=10, thr= 26.12, gain=0.143741
tree= 1, node= 37, feature= 8, thr= 51.04, gain=0.269175
tree= 1, node= 38, feature=10, thr= 53.22, gain=0.426593
tree= 1, node= 39, feature=16, thr= 12.94, gain=0.666706
tree= 1, node= 40, feature= 3, thr= 33.33, gain=0.045760
tree= 1, node= 41, feature=13, thr= 45.10, gain=0.069191
tree= 1, node= 42, feature= 3, thr= 27.24, gain=0.129612
tree= 1, node= 43, feature= 7, thr= 34.59, gain=0.862068
tree= 1, node= 44, feature= 6, thr= 86.24, gain=0.120379
tree= 1, node= 45, feature= 3, thr= 96.18, gain=0.089385
tree= 1, node= 46, feature=15, thr= 25.67, gain=0.134332
tree= 1, node= 47, feature=16, thr= 21.67, gain=0.128405
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classification accuracy=0.8557

TASK 2

Part a):

Given, 80 people decided to wait, and 20 people decided not to wait. Entropy of parent node A is given by,

$$H(A) = H\left(\frac{80}{100}, \frac{20}{100}\right) = -(0.8 \log_2(0.8)) - (0.2 \log_2(0.2)) = \mathbf{0.7219}$$

Part b):

On the child cases

For Node B, 20 waited and 15 didn't if it was weekend.

For Node C, 60 waited and 5 didn't if it was not weekend.

$$\text{Entropy at node B} = H(B) = H\left(\frac{20}{35}, \frac{15}{35}\right) = -\left(\frac{20}{35} \log_2\left(\frac{20}{35}\right)\right) - \left(\frac{15}{35} \log_2\left(\frac{15}{35}\right)\right) = 0.9852$$

$$\text{Entropy at node C} = H(C) = H\left(\frac{60}{65}, \frac{5}{65}\right) = -\left(\frac{60}{65} \log_2\left(\frac{60}{65}\right)\right) - \left(\frac{5}{65} \log_2\left(\frac{5}{65}\right)\right) = 0.3912$$

$$\text{Information gain} = H(A) - \left(\frac{35}{100} H(B) + \frac{65}{100} H(C)\right) = \mathbf{0.1228}$$

Information gain for the weekend test at Node A is 0.1228.

Part c):

Information gain at Node E is 0.

Part d):

The test case hungry patron who came in a rainy Tuesday end up in **Node F**. The decision tree output for that case is **"will wait"**.

Part e)

The test case not hungry patron who came in a sunny Saturday end up in **Node H**. The decision tree output for that case is **"will not wait"**.

TASK3

For parent class there are 5 X's and 5 Y's

$$H(p) = H\left(\frac{5}{10}, \frac{5}{10}\right) = -(0.5 \log_2(0.5)) - (0.5 \log_2(0.5)) = 1$$

There are three attributes A, B and C.

So for A, when A=1 \rightarrow X=3, Y=0

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

For A, when A=2 \rightarrow X=1, Y=3

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

For A, when A=3 \rightarrow X=1, Y=2

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

$$\text{Information gain using A} = \left[\frac{3}{10} (0) + \frac{4}{10} (0.811278) + \frac{3}{10} (0.918296) \right] = 0.4$$

FOR B

when B=1 \rightarrow X=1, Y=3

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

For B, when B=2 \rightarrow X=3, Y=1

$$H(B2) = 0.8113$$

For A, when B=3 \rightarrow X=1, Y=1

$$H(B3) = (0.5 \log_2(0.5)) - (0.5 \log_2(0.5)) = 1$$

$$\text{Information gain using B} = 1 - \left[\frac{4}{10} (0.811278) + \frac{4}{10} (0.811278) + \frac{2}{10} (1) \right] = 0.1510$$

FOR C

when C=1 \rightarrow X=1, Y=4

$$H(A1) = H\left(\frac{1}{5}, \frac{4}{5}\right) = -\left(\frac{1}{5} \log_2\left(\frac{1}{5}\right)\right) - \left(\frac{4}{5} \log_2\left(\frac{4}{5}\right)\right) = 0.7219$$

For C, when C=2 \rightarrow X=3, Y=1

$$H(C2) = 0.8113$$

For C, when C=3 \rightarrow X=1, Y=0

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

$$\text{Information gain using C} = 1 - \left[\frac{5}{10} (0.721928) + \frac{4}{10} (0.811278) + \frac{1}{10} (0) \right] = 0.3145$$

Therefore, comparing the information gain of A, B and C:

$$A > C > B \rightarrow 0.4 > 0.3145 > 0.1510$$

Here, Attribute A achieves the highest information gain at the root.

TASK4

Part a):

Highest possible entropy value at Node N with 4 class labels = $\log_2 N = \log_2 4 = 2$

Lowest possible entropy value at Node N = 0

Part b):

Highest possible information gain at Node N when chosen attribute K is the **entropy at node N** when sum of all the child node results to 0 as information gain equals entropy of parent subtracting sum of weighted entropy of all the child Node.

Lowest possible information gain at Node N is 0 when entropy at node N is equal to weighted sum of entropy of all the child Node.

TASK 5

As the given classifier is binary, classifier gives 28% accuracy meaning it gives wrong answer 72%. So, we can achieve the accuracy better than 60% by flipping the answer of the classifier. By this, classifier can give guaranteed accuracy of 72% which is better than 60% accuracy.