Problem 1 (max 10). Suppose we know that:

- If Paolo is thin, then Carlo is not blonde or Roberta is not tall
- If Roberta is tall then Sandra is lovely
- If Sandra is lovely and Carlo is blonde then Paolo is thin
- Carlo is blonde

Can we deduce that Roberta is not tall?

Solution:
A – Paolo is thin. C – Carlo is blonde. R – Roberta is tall. S – Sandra is lovely.
We need to check if
KB = { A → (~C v ~R), R → S, (S ^ C) → A, C } |- ~R
Converting to set of clauses (5 points) & use resolution. (5 points)

1. ~A v ~C v ~R
2. ~R v S
3. ~S v ~C v A
4. C
5. R

Resolution:
6. = (1)+(4)+(5) ~A;
7. = (2)+(5) S;
8. = (3)+(4)+(6) ~S;
(7)+(8) NIL

Problem 2 (max 10). In what order the algorithm using distance function f(n) will visit nodes in the graph G assuming that A is the starting node and G is the final node in the graph. We assume that f(n) = g(n) + h(n), where g(n) is the shortest distance from node A to node n (n ∈ {B, C, D, E, F, G}) and function h is defined by the table below. Function h(x) is a heuristic estimation of the distance from node x to the final node.
Check if $f(n)$ is **admissible** (never overestimates the actual cost to get from node $n$ to the goal) [2 points out of 10] and **monotonic** [2 points out of 10]

Solution:

<table>
<thead>
<tr>
<th></th>
<th>h(B)</th>
<th>h(C)</th>
<th>h(D)</th>
<th>h(E)</th>
<th>h(F)</th>
<th>h(G)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>7</td>
<td>5</td>
<td>6</td>
<td>4</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

(A $\rightarrow$ C, $2+h(C)=8$), (A$\rightarrow$C$\rightarrow$E, 11), (A$\rightarrow$C$\rightarrow$D, 10)

(A $\rightarrow$ B, 8)

Monotonic: $h(A) = 7 \leq d(A,C)+h(C)=2+ 6 = 8$

Admissible: $h(A)= 7 \leq d(A,G)=9$

(A $\rightarrow$ C, $2+h(C)=8$), (A$\rightarrow$C$\rightarrow$E, 11), (A$\rightarrow$C$\rightarrow$D, 10)

(A $\rightarrow$ B, 8), (A$\rightarrow$B$\rightarrow$ D, 9)

Monotonic: $h(A) = 7 \leq d(A,B)+d(B) =3 + 5 = 8$

Admissible: $h(A)= 5 \leq d(B,G)= 6$

(A $\rightarrow$ C, $2+h(C)=8$), (A$\rightarrow$C$\rightarrow$E, 11), (A$\rightarrow$C$\rightarrow$D, 10)

(A $\rightarrow$ B, 8), (A$\rightarrow$B$\rightarrow$ D, 9), (A$\rightarrow$B$\rightarrow$D$\rightarrow$E, 12), (A$\rightarrow$B$\rightarrow$D$\rightarrow$F, 9)

Monotonic: $h(B)=5 \leq d(B,D) + h(D) = 2 + 4 = 6$

Admissible: $h(B) = 5 \leq d(B,G) = 6$

(A $\rightarrow$ C, $2+h(C)=8$), (A$\rightarrow$C$\rightarrow$E, 11), (A$\rightarrow$C$\rightarrow$D, 10)

(A $\rightarrow$ B, 8), (A$\rightarrow$B$\rightarrow$ D, 9), (A$\rightarrow$B$\rightarrow$D$\rightarrow$E, 12), (A$\rightarrow$B$\rightarrow$D$\rightarrow$F$\rightarrow$G, 9)

Monotonic: $h(D) = 4 \leq d(D,F) + h(F) = 2 + 2 = 4$

Admissible: $h(D) = 4 \leq d(D,G) = 4$

(A $\rightarrow$ C, $2+h(C)=8$), (A$\rightarrow$C$\rightarrow$E, 11), (A$\rightarrow$C$\rightarrow$D, 10)

(A $\rightarrow$ B, 8), (A$\rightarrow$B$\rightarrow$ D, 9), (A$\rightarrow$B$\rightarrow$D$\rightarrow$E, 12), (A$\rightarrow$B$\rightarrow$D$\rightarrow$F$\rightarrow$G, 9)

Monotonic: $h(F) = 2 \leq d(F,G) + h(G) = 2 + 0$
Problem 3 (max 12).

Let’s assume that:

1) Anyone whom Mary loves is a football star.
2) Any student who does not pass does not play.
3) John is a student.
4) Any student who does not study does not pass.
5) Anyone who does not play is not a football star.

Use resolution to prove that: If John does not study, then Mary does not love John.

To what class (Breadth-First, Set-of-Support, Unit-Preference, Linear-Input Form, Ancestry-Filtered Form) does your strategy belong? List all.

Use the following alphabet:

Constants: M – Mary, J- John,

Predicates: S(x) – x is a student, ML(x) – Mary loves x

F(x) – x is a football star, St(x) – x does not study,

Play(x) – x does not play, Pass(x) – x does not pass.

KB: Knowledge Base

ML(x) -> F(x). (S(x) ^ Pass(x)) -> Play(x).
S(John). (S(x) ^ St(x)) -> Pass(x). Play(x) -> ~F(x).

Prove that:

St(John) -> ~ML(John).

Converting KB to the Set of Clauses + Negation of the Goal (max 4 points)

~ML(x) v F(x). ~S(x) v ~Pass(x) v Play(x).
S(John). ~S(x) V ~St(x) v Pass(x). ~Play(x) v ~F(x). St(John). ML(John)
Resolution. (max 5 points)

Resolution belongs to the following classes: linear-input, unit-preference, & set-of-support. (max 3 points)

Problem 4 (max 8). Assuming that the procedure graph for surgery P1 is represented by the figure below, find the score associated with a surgery P3 (the average number of readmissions to hospital after surgery P3).

Remark: Out of 300 patients having surgery P1, 20 are fine, 100 returned to the hospital for surgery P2, 150 for surgery P5, and 30 for surgery P3.
Solution:

Score(P9) = 8/8*0 = 0
Score(P7) = 6/12[1 + Score(P9)] + 6/12*0 = ½
Score(P10) = 3/3*0 = 0
Score(P8) = 3/6*0 + 3/6[1 + Score(P10)] = ½

Score(P5) = 5/20*0 + 10/20[1 + Score(P7)] + 5/20[1 + Score(P8)] =

Score(P6) = 1*[1 + Score(P8)] = 3/2

Score(P3) = 1/3*0 + 1/3*[1 + Score(P6)] + 1/3*[1 + Score(P5)] =

Score(P4) = 2/4*[1 + Score(P9)] + 2/4*[1 + Score(P7)] = ½*[1+0] + ½*[1+ ½] =
½ + ½*3/2 = 2/4 + ¾ = 5/4

Score(P2) = 2/10*0 + 4/10*[1 + Score(P4)] + 4/10*[1 + Score(P5)] =
18/20 + 17/20 = 35/20 = 7/4
Score(P1) =
\[ \frac{2}{30} \cdot 0 + \frac{1}{3} \cdot [1 + \text{Score(P2)}] + \frac{1}{2} \cdot [1 + \text{Score P(5)}] + \frac{1}{10} \cdot [1 + \text{Score (P3)}] = \]
\[ \frac{1}{3} \cdot [1 + \frac{7}{4}] + \frac{1}{2} \cdot [1 + \frac{9}{8}] + \frac{1}{10} \cdot [1 + \frac{37}{24}] = \]
\[ \frac{1}{12} + \frac{17}{16} + \frac{61}{240} \]

(If calculation mistakes, drop 1 point. If the strategy is correct but the solution is not finished, drop 2 points. If strategy is wrong, drop 5 points)