

## MAP30#1 — Reliability of a four-engined aircraft

### Question 1 (Reliability block) diagram

```
In[13]:= Show[Graphics[{
  Circle[{2, 2}, 1],
  Circle[{2, -2}, 1],
  Circle[{7, 2}, 1],
  Circle[{7, -2}, 1],

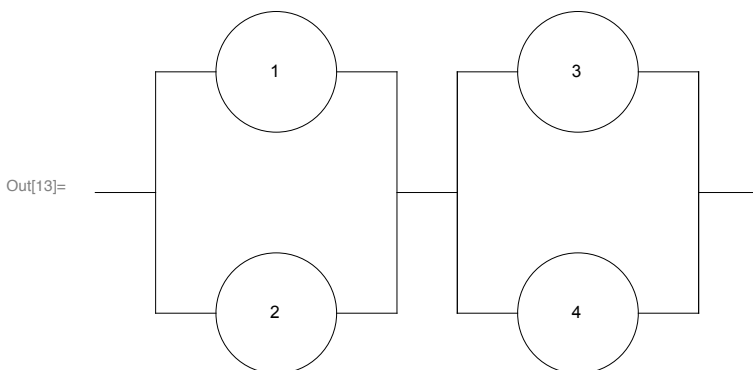
  Text["1", {2, 2}],
  Text["2", {2, -2}],
  Text["3", {7, 2}],
  Text["4", {7, -2}],

  Line[{{-1, 0}, {0, 0}}],
  Line[{{4, 0}, {5, 0}}],
  Line[{{9, 0}, {10, 0}}],

  Line[{{0, -2}, {0, 2}}],
  Line[{{4, -2}, {4, 2}}],
  Line[{{5, -2}, {5, 2}}],
  Line[{{5, -2}, {5, 2}}],
  Line[{{9, -2}, {9, 2}}],
  Line[{{9, -2}, {9, 2}}],

  Line[{{0, 2}, {1, 2}}],
  Line[{{3, 2}, {4, 2}}],
  Line[{{0, -2}, {1, -2}}],
  Line[{{3, -2}, {4, -2}}],

  Line[{{5, -2}, {6, -2}}],
  Line[{{8, -2}, {9, -2}}],
  Line[{{5, 2}, {6, 2}}],
  Line[{{8, 2}, {9, 2}}]
}]]
```



## Reliability

```
In[14]:= ClearAll["Global`*"]
Raircraft = ReliabilityDistribution[(X1 ∨ X2) ∧ (X3 ∨ X4),
  {{X1, BernoulliDistribution[p1]}, {X2, BernoulliDistribution[p2]},
  {X3, BernoulliDistribution[p3]}, {X4, BernoulliDistribution[p4]}}];
Mean[Raircraft]
```

Out[16]=  $(-p_1 - p_2 + p_1 p_2) (-p_3 - p_4 + p_3 p_4)$

## Reliability importance of engine I

```
In[17]:= D[p1, Mean[Raircraft]]
```

Out[17]=  $(-1 + p_2) (-p_3 - p_4 + p_3 p_4)$

## Upper bounds, etc.

```
In[26]:= p1 = p2 = p3 = p4 = p;
U68[p_] = 1 - (1 - p^2)^4;
U70[p_] = 1 - (1 - p)^2;
r[p_] = Mean[Raircraft]
```

```
r[0.9]
U68[0.9]
U70[0.9]
```

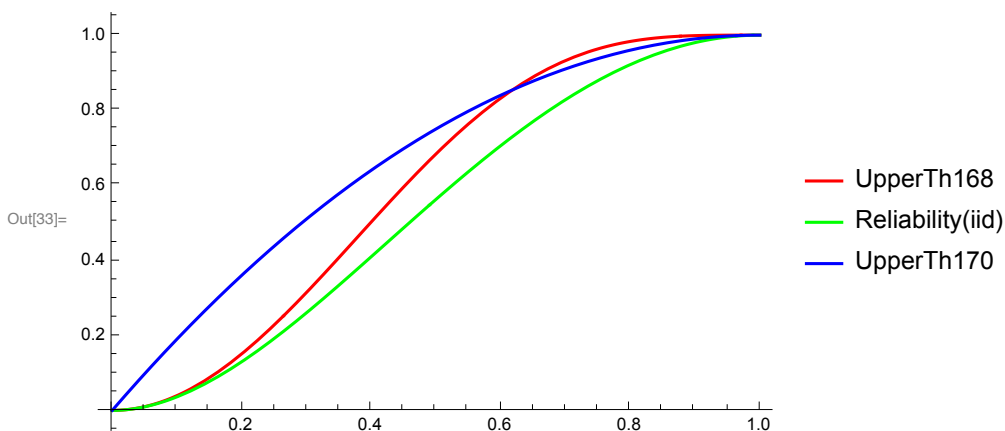
```
Plot[{U68[p], r[p], U70[p]}, {p, 0, 1},
  PlotLegends → Placed[{"UpperTh168", "Reliability(iid)", "UpperTh170"}, Right],
  PlotStyle → {Red, Green, Blue}]
```

Out[29]=  $(-2 p + p^2)^2$

Out[30]= 0.9801

Out[31]= 0.998697

Out[32]= 0.99



## Question 2

### Reliability function and expected duration

```
In[34]:= dist = ExponentialDistribution[1];
Raircraft = ReliabilityDistribution[
  (X1 ∨ X2) ∧ (X3 ∨ X4), {{X1, dist}, {X2, dist}, {X3, dist}, {X4, dist}}];
SurvivalFunction[Raircraft, t]
Mean[Raircraft]
```

```
Out[36]= 
$$\begin{cases} 1 & t < 0 \\ \left(1 - (1 - e^{-t})^2\right)^2 & \text{True} \end{cases}$$

```

```
Out[37]= 
$$\frac{11}{12}$$

```