Question 1

- *mutually exclusive events* are events that cannot occur simultaneously, meaning they are dependent - or the state of one event effects the state of the other
  independent events are events that do not influence each other in any way, or the state of one event does not impact the state of the other

Question 2

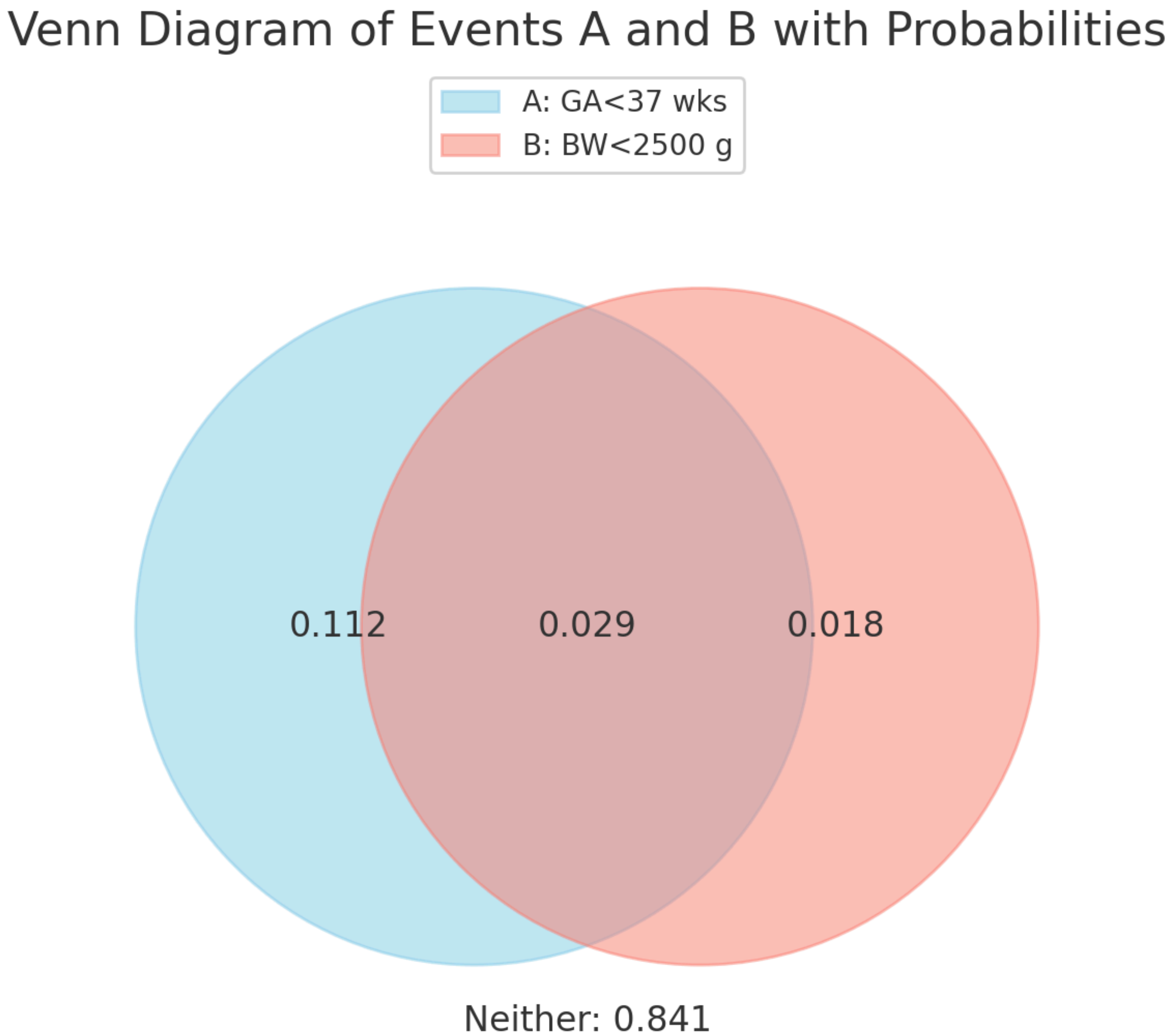
> I use the following terminology because I've worked with Bayesian networks in my research work. I love Bayesian!

- Traditional probabilistic operations "feed forward," or allow you to predict *effect* from *cause*.
- *Bayes Theorem* let's you **reverse the conditional** or calculate *cause from effect
- In diagnostic testing, you can use *priors*, or the already known knowledge of *prevalence, sensitivity, and specificity* to calculate positive and negative predictive value(s) in non-representative samples.

Question 3

$$\begin{aligned} P(G) &= 0.141 && \text{where } G = \{\text{gestational age } < 37 \text{ weeks}\}, \\ P(W) &= 0.047 && \text{where } W = \{\text{birth weight } < 2500 \text{ g}\}, \\ P(G \cap W) &= 0.029 && \text{(both events occur)}. \end{aligned}$$

A:



> Made using Python and Matplotlib
> CODE BELOW

```
import matplotlib.pyplot as plt

# Given probabilities
P_A = 0.141
P_B = 0.047
P_A_and_B = 0.029
```

```
# Derived probabilities
P_only_A = P_A - P_A_and_B
P_only_B = P_B - P_A_and_B
P_neither = 1 - (P_only_A + P_only_B + P_A_and_B)

# Plot Venn diagram manually using circles
fig, ax = plt.subplots(figsize=(6,6))

# Draw circles
circle_A = plt.Circle((0.4,0.5), 0.3, color='skyblue', alpha=0.5, label='A: GA<37 wks')
circle_B = plt.Circle((0.6,0.5), 0.3, color='salmon', alpha=0.5, label='B: BW<2500 g')
ax.add_artist(circle_A)
ax.add_artist(circle_B)

# Annotate probabilities
ax.text(0.28,0.5, f"{P_only_A:.3f}", ha='center', va='center', fontsize=12)
ax.text(0.72,0.5, f"{P_only_B:.3f}", ha='center', va='center', fontsize=12)
ax.text(0.5,0.5, f"{P_A_and_B:.3f}", ha='center', va='center', fontsize=12)
ax.text(0.5,0.15, f"Neither: {P_neither:.3f}", ha='center', va='center', fontsize=12)

# Formatting
ax.set_xlim(0,1)
ax.set_ylim(0,1)
ax.set_aspect('equal')
ax.axis('off')
ax.legend(loc='upper center')
plt.title("Venn Diagram of Events A and B with Probabilities")
plt.tight_layout()
plt.show()
```

B:Two events are independent if $P(A|B) = P(A)$.

- $P(A|B) = \frac{P(A \cap B)}{P(B)} = \frac{0.029}{0.047} = 0.617 \neq P(A)$

- these two events are **dependent**

C: Probability of A or B or Both occuring is

$$P(A) + P(B) - (A \cap B) = 0.141 + 0.047 - 0.029 = 0.159 \text{ OR } 1 - 0.841 = 0.159$$

```
- **0.159**
```

D: $P(A|B) = \frac{P(A \bigcap B)}{P(B)} = \frac{0.029}{0.047} = 0.617$

Question 4

$$\text{Sensitivity } (Se) = P(\text{Test}+ \mid \text{Disease}) = 0.72,$$
$$\text{Specificity } (Sp) = P(\text{Test}- \mid \text{No Disease}) = 0.60.$$

A:

$$\text{PPV} = P(D \mid T^+) = \frac{Se \times Prev}{Se \times Prev + (1 - Sp) \times (1 - Prev)},$$

$$\text{NPV} = P(D^c \mid T^-) = \frac{Sp \times (1 - Prev)}{Sp \times (1 - Prev) + (1 - Se) \times Prev}.$$

$$\text{For } Prev = 0.17 :$$
$$\text{PPV} = \frac{Se \times 0.17}{Se \times 0.17 + (1 - Sp) \times (1 - 0.17)},$$
$$\text{NPV} = \frac{Sp \times (1 - 0.17)}{Sp \times (1 - 0.17) + (1 - Se) \times 0.17};$$

$$\text{PPV} = 0.270$$
$$\text{NPV} = 0.913$$

B:

$$\text{For } Prev = 0.12 :$$
$$\text{PPV} = \frac{Se \times 0.12}{Se \times 0.12 + (1 - Sp) \times (1 - 0.12)},$$
$$\text{NPV} = \frac{Sp \times (1 - 0.12)}{Sp \times (1 - 0.12) + (1 - Se) \times 0.12};$$

$$\text{PPV} = 0.197$$
$$\text{NPV} = 0.940$$

$$\text{For } Prev = 0.07 :$$
$$\text{PPV} = \frac{Se \times 0.07}{Se \times 0.07 + (1 - Sp) \times (1 - 0.07)},$$
$$\text{NPV} = \frac{Sp \times (1 - 0.07)}{Sp \times (1 - 0.07) + (1 - Se) \times 0.07};$$
$$\text{PPV} = 0.119$$
$$\text{NPV} = 0.966$$

C:

Question 5

Method	Probability of Pregnancy
None	0.430
Diaphragm	0.152
Condom	0.099
IUD	0.065
Phil	0.036

$X = \text{Pregnant}$
$X^C = \text{Not Pregnant}$
$M = \text{Method of Contraception}$
$M^C = \text{No Contraception Used}$

$$RR = \frac{P(X|M)}{P(X|M^C)}$$

After plugging in $P(X|M)$ and $P(X|M^C)$ for each method we get the following

METHOD	RELATIVE RISK (RR)
Diaphragm	0.353
Condom	0.230
IUD	0.151
Phil	0.083

Question 6

- $A \cap B$ is the *intersection* between A and B or the probability of both A **AND** B occurring simultaneously
- $A \cup B$ is the *union* between A and B or the probability of either A **OR** B occuring
- A^C is the event that the individual **is not** pregnant
- **No**. They are not mutually exclusive. They would only be if they could not occur simultaneously, which is not the case.

Question 7

TODO:

- [ ] calculate A

- [ ] calculate B

A: $P(X < 29) = \sum P(\text{group}) \quad \text{where group} < 29 \quad = 0.301 + 0.228 + 0.082 + 0.001 = x$
B: $P(X > 35) = \sum P(\text{group}) \quad \text{where group} > 35 \quad = 0.110 + 0.031 + 0.002 = y$
C:

Age Probability
<15 0.001
15–19 0.082
20–24 0.228
25–29 0.301
30–34 0.245
35–39 0.110
40–44 0.031
45–54 0.002
Total 1.000

(c) Given that the mother of a particular child was under 30 years of age, what is the probability
that she was older than 19?
(d) Given that the mother was 30 years of age or older, what is the probability that she was under
40?