# 1.2.26

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# Question

Rain is falling vertically with a speed of 35 $ms^{-1}$. A woman rides a bicycle with a speed of 12 $ms^{-1}$ in east to west direction. What is the direction in which she should hold her umbrella ?

# Theoretical Solution

**Solution:**

Velocity of rain $\overrightarrow{v}_{rain} = \begin{pmatrix} 0 \\ -35 \end{pmatrix}$

Velocity of woman $\overrightarrow{v}_{woman} = \begin{pmatrix} -12 \\ 0 \end{pmatrix}$

The relative velocity of rain with respect to the woman is: $\overrightarrow{v}_{rel} = \overrightarrow{v}_{rain} - \overrightarrow{v}_{woman}$

$= \begin{pmatrix} 0 \\ -35 \end{pmatrix} - \begin{pmatrix} -12 \\ 0 \end{pmatrix} = \begin{pmatrix} 12 \\ -35 \end{pmatrix}$

Let $\overrightarrow{a} = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$

# Theoretical Solution

Let $\theta$ be the angle with horizontal

$$\cos\theta = \frac{a^T v_{rel}}{||a||v_{rel}||}$$

$$\cos\theta = \frac{12}{37}$$

# C Code

```c
#include <stdio.h>
#include <math.h>

int main() {
    // Components of the relative velocity vector
    double vx = 12.0; // horizontal component
    double vy = -35.0; // vertical component

    // Calculate magnitude of relative velocity vector
    double magnitude = sqrt(vx * vx + vy * vy);

    // Calculate cos(theta)
    double cos_theta = vx / magnitude;

    // Output result
    printf("cos(theta) = %.5f\n", cos_theta);

    return 0;
```

# Python Code

```
import matplotlib.pyplot as plt
from mpl_toolkits.mplot3d import Axes3D
import numpy as np

# Define vector components
rain_velocity = np.array([0, 0, -35]) # Rain falling vertically
woman_velocity = np.array([-12, 0, 0]) # Woman moving east to
    west
relative_velocity = rain_velocity - woman_velocity # Relative
    velocity of rain w.r.t woman

# Origin point for vectors
origin = np.array([0, 0, 0])

# Plot setup
fig = plt.figure(figsize=(10, 8))
ax = fig.add_subplot(111, projection='3d')
```

# Python Code

```
# Plot rain velocity vector (blue)
ax.quiver(*origin, *rain_velocity, color='blue', label='Rain
    Velocity', arrow_length_ratio=0.1)

# Plot woman velocity vector (green)
ax.quiver(*origin, *woman_velocity, color='green', label='Woman
    Velocity', arrow_length_ratio=0.1)

# Plot relative velocity vector (red)
ax.quiver(*origin, *relative_velocity, color='red', label='
    Relative Velocity (Umbrella Direction)', arrow_length_ratio
    =0.1)

# Set axis labels
ax.set_xlabel('X (East-West)')
ax.set_ylabel('Y (North-South)')
ax.set_zlabel('Z (Vertical)')
```

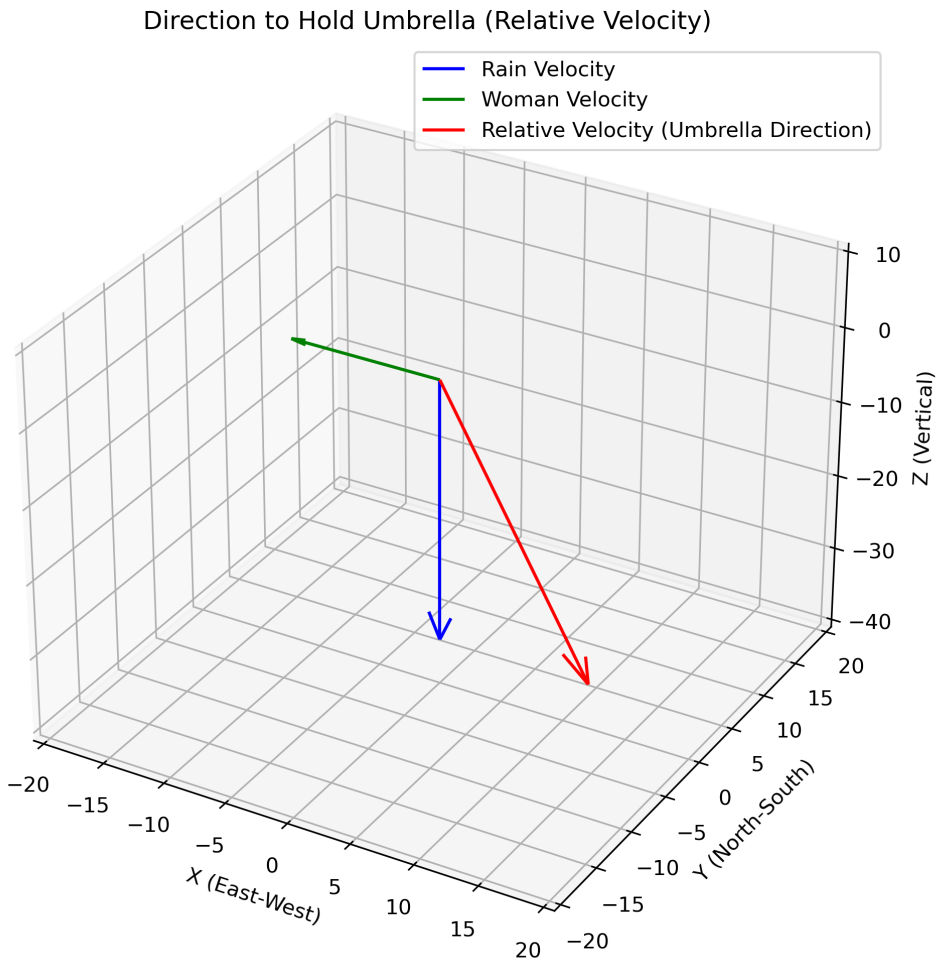
# Python Code

```
# Set plot limits
ax.set_xlim([-20, 20])
ax.set_ylim([-20, 20])
ax.set_zlim([-40, 10])

# Title and legend
ax.set_title('Direction to Hold Umbrella (Relative Velocity)')
ax.legend()

# Save the figure as an image
plt.savefig("fig.png", dpi=300)
# Show the plot
plt.show()
```

# Plot


Direction to Hold Umbrella (Relative Velocity)
Rain Velocity
Woman Velocity
Relative Velocity (Umbrella Direction)
X (East-West)
Y (North-South)
Z (Vertical)
−20
−15
−10
−5
0
5
10
15
20
10
0
−10
−20
−30
−40