```
import numpy as np
from scipy.ndimage import correlate
from skimage import color, data
import matplotlib.pyplot as plt

original_image = data.astronaut()
```

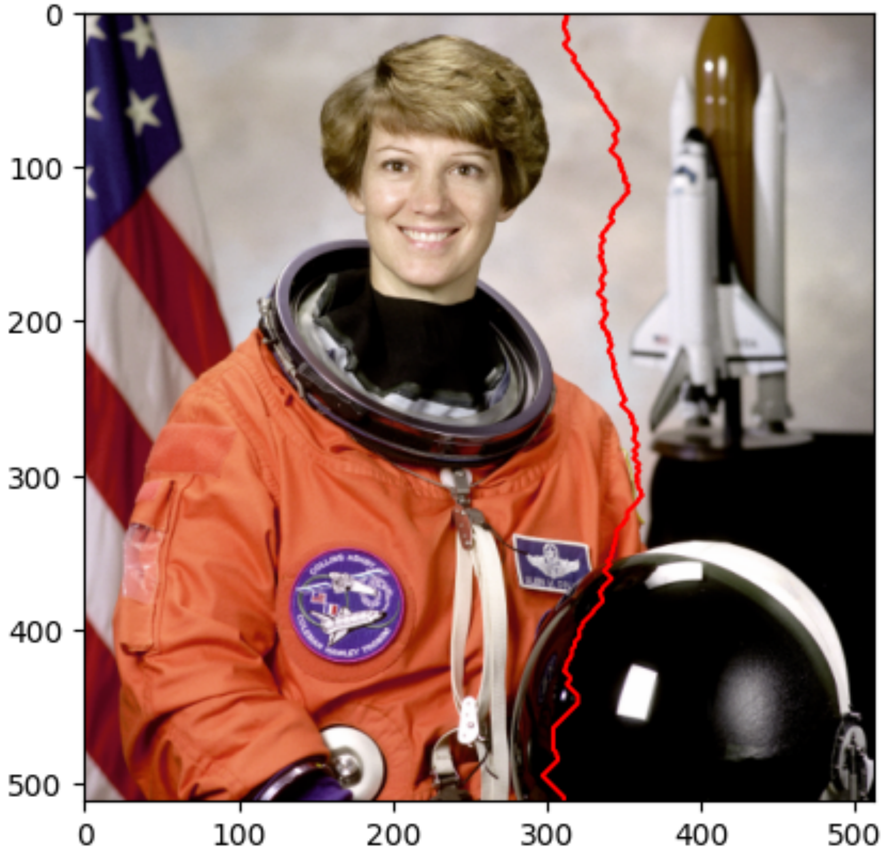
Q1 (a) Compute magnitude of gradient

```
def gradient_magnitude_computation(image: np.ndarray) -> np.ndarray:
    if len(image.shape) > 2:
        image = color.rgb2gray(image)

    sobel_x = np.array([[-1, 0, 1],
                        [-2, 0, 2],
                        [-1, 0, 1]])
    sobel_y = np.array([[1, 2, 1],
                        [0, 0, 0],
                        [-1, -2, -1]])

    gradient_x = correlate(image, sobel_x, mode='constant')
    gradient_y = correlate(image, sobel_y, mode='constant')

    magnitude = np.sqrt(gradient_x**2 + gradient_y**2)

    return magnitude
```

Q1 (b) Find min seam path

```
def find_min_seam_path(image: np.ndarray) -> np.ndarray:
    gradient_magnitude = gradient_magnitude_computation(image)
    rows, cols = gradient_magnitude.shape

    cumulative_min_energy = gradient_magnitude.copy()
    backtrack = np.zeros((rows, cols), int)
    for i in range(1, rows):
        for j in range(cols):
            if j == 0:
```

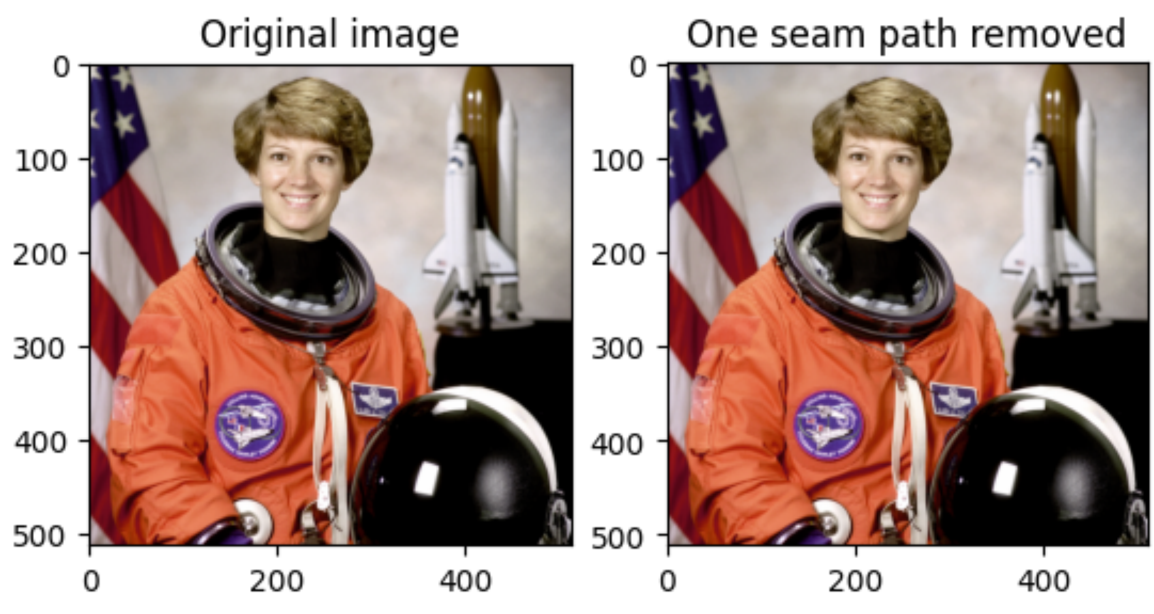
```
                neighbors = [j, j + 1]
            elif j == cols - 1:
                neighbors = [j - 1, j]
            else:
                neighbors = [j - 1, j + 1]

            min_index = np.argmin(cumulative_min_energy[i-1, neighbors[0]:neighbo
            actual_min_index = neighbors[0] + min_index
            backtrack[i,j] = actual_min_index
            cumulative_min_energy[i, j] += cumulative_min_energy[i-1, actual_min_

    col = np.argmin(cumulative_min_energy[-1])
    min_seam = []
    for row in range(rows-1, -1, -1):
        min_seam.append([row,col])
        col = int(backtrack[row, col])
    return np.array(min_seam[::-1])

seam_path = find_min_seam_path(original_image)

plt.imshow(original_image)
plt.plot(seam_path[:, 1], seam_path[:, 0], 'r')
plt.show()
```



Q1 (c) Remove first seam path

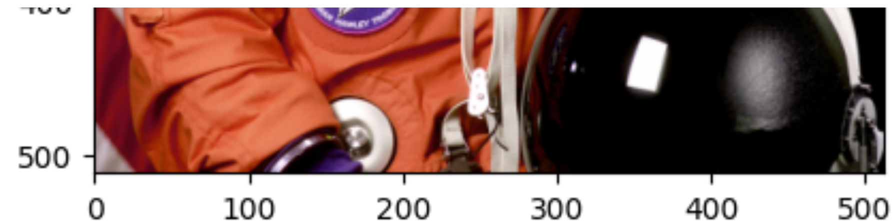
```
def remove_path(image: np.ndarray, path: np.ndarray) -> np.ndarray:
    # if len(image.shape) > 2:
    #     image = color.rgb2gray(image)

    rows, cols, z = image.shape
    new_image = np.zeros((rows, cols-1, z))
    for i in range(len(path)):
        new_image[i,:,:] = np.delete(image[i,:,:], path[i, 1], axis=0)

    return new_image.astype(np.uint8)

new_image = remove_path(original_image, find_min_seam_path(original_image))
print(f"Original image shape: {original_image.shape}")
print(f"Image shape after removing {num_paths} seam paths: {new_image.shape}")

f, axarr = plt.subplots(1, 2)
axarr[0].imshow(original_image)
axarr[0].set_title("Original image")
axarr[1].imshow(new_image)
axarr[1].set_title("One seam path removed")
plt.show()
```

```
Original image shape: (512, 512, 3)
Image shape after removing 50 seam paths: (512, 511, 3)
```



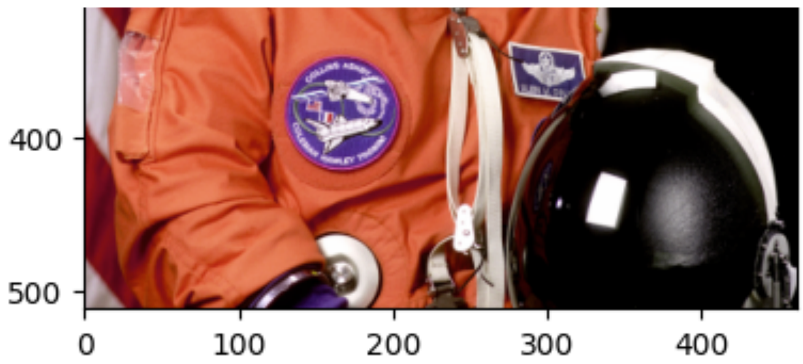
Q1 (d) Removing few seam paths

```
def remove_seam_paths(image: np.ndarray, n: int) -> np.ndarray:
    new_image = image.copy()
    all_paths = []
    for _ in range(n):
        seam_path = find_min_seam_path(new_image)
        all_paths.append(seam_path)
        new_image = remove_path(new_image, seam_path)
    return new_image

plt.imshow(original_image)
plt.title("Original image")
plt.show()

num_paths = 20
new_image = remove_seam_paths(original_image, num_paths)
print(f"Original image shape: {original_image.shape}")
print(f"Image shape after removing {num_paths} seam paths: {new_image.shape}")
plt.imshow(new_image)
plt.title(f"{num_paths} seam path removed")
plt.show()

num_paths = 30
new_new_image = remove_seam_paths(new_image, num_paths)
print(f"Image shape after removing {num_paths} additional seam paths: {new_new_imag
plt.imshow(new_new_image)
plt.title(f"{num_paths} seam path removed")
plt.show()
```



```
Original image shape: (512, 512, 3)
Image shape after removing 20 seam paths: (512, 492, 3)
```


```
Image shape after removing 30 additional seam paths: (512, 462, 3)
```



Q2 Mathematical form of convolution filter F that upscaled an image by a factor of d:

$$h = \left[0, \frac{1}{d}, \frac{2}{d}, \dots, \frac{d-1}{d}, 1, \frac{d-1}{d}, \dots, \frac{2}{d}, \frac{1}{d}, 0 \right]$$

h(plot) =