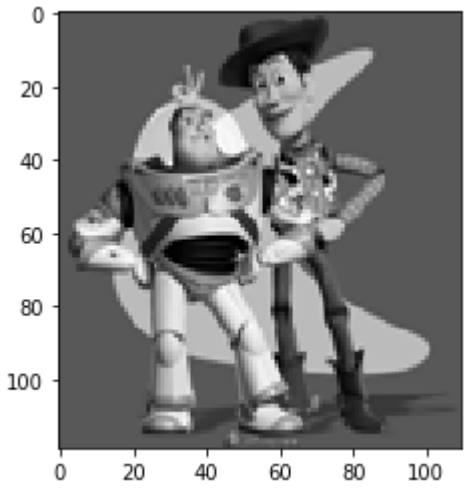
In [1]:
```
import cv2
import time
import numpy as np
from scipy.sparse import csr_matrix
from scipy.sparse import lil_matrix
from scipy.sparse.linalg import lsqr
%matplotlib inline
import matplotlib.pyplot as plt
from utils import *
import os
```

In [2]:
```
toy_img = cv2.cvtColor(cv2.imread('samples/toy_problem.png'), cv2.COLOR_
toy_img = cv2.cvtColor(toy_img, cv2.COLOR_BGR2GRAY).astype('double') / 2
plt.imshow(toy_img, cmap="gray")
```

Out[2]: <matplotlib.image.AxesImage at 0x7f26d022e790>



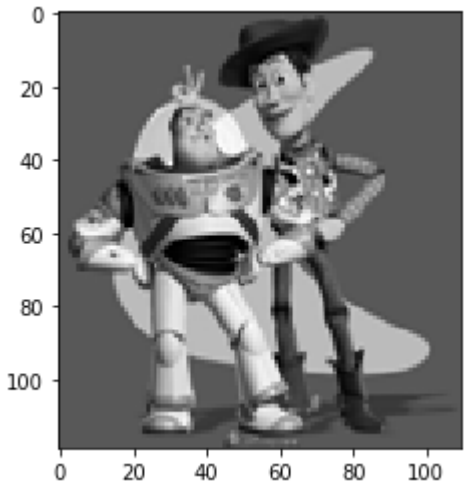
Part 1 Toy Problem (20 pts)

In [78]:
```
def toy_reconstruct(toy_img):
    """
    The implementation for gradient domain processing is not complicated
    1. minimize (v(x+1,y)-v(x,y) - (s(x+1,y)-s(x,y)))^2
    2. minimize (v(x,y+1)-v(x,y) - (s(x,y+1)-s(x,y)))^2
    Note that these could be solved while adding any constant value to v
    3. minimize (v(1,1)-s(1,1))^2

    :param toy_img: numpy.ndarray
    """
    im=toy_img
    im_h, im_w = toy_img.shape
    im2var = np.arange(im_h * im_w).reshape(im_w, im_h).T
    num_v = (im_h)*(im_w)
    num_e = im_h*(im_w-1) + im_w*(im_h-1) + 1
    #A = np.zeros((num_e,num_v))
    A = lil_matrix((num_e,num_v))
    b = np.zeros((num_e,))
    e=0
    for x in range(im_w):
        for y in range(im_h):
            if x < im_w-1:
                A[e,im2var[y][x+1]] = 1
                A[e,im2var[y][x]] = -1
                b[e] = im[y][x+1] - im[y][x]
                e+=1
            if y < im_h-1:
                A[e,im2var[y+1][x]] = 1
                A[e,im2var[y][x]] = -1
                b[e] = im[y+1][x] - im[y][x]
                e+=1

    A[e,im2var[0][0]] = 1
    b[e] = im[0][0]
    A=A.tocsr()
    v = lsqr(A, b)

    return v[0].reshape((im_w, im_h)).T
```

In [79]:
```
im_out = toy_reconstruct(toy_img)

if im_out.any():
    print("Error is: ", np.sqrt(((im_out - toy_img)**2).sum()))

plt.close()
plt.imshow(im_out, cmap="gray")
```

```
Error is:  0.00031701850068623744
```

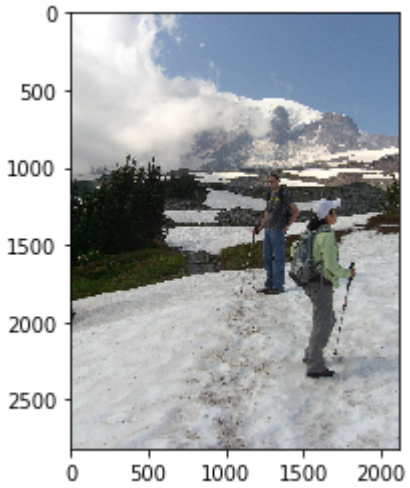
Out[79]:
```
<matplotlib.image.AxesImage at 0x7f26c40e7590>
```



Preparation

In [5]:
```
# Feel free to change image
background_img = cv2.cvtColor(cv2.imread('samples/im2.JPG'), cv2.COLOR_B
plt.figure()
plt.imshow(background_img)
```

Out[5]: <matplotlib.image.AxesImage at 0x7f26cfd072d0>



In [7]:
```
# Feel free to change image
object_img = cv2.cvtColor(cv2.imread('samples/penguin-chick.jpeg'), cv2.
import matplotlib.pyplot as plt
%matplotlib notebook
mask_coords = specify_mask(object_img)
```

```
If it doesn't get you to the drawing mode, then rerun this function ag
ain.
```

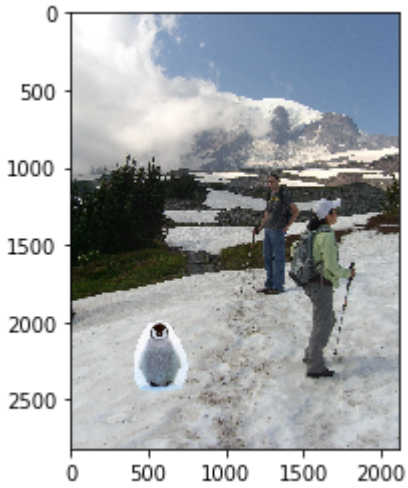
In [8]:
```
xs = mask_coords[0]
ys = mask_coords[1]
%matplotlib inline
import matplotlib.pyplot as plt
plt.figure()
mask = get_mask(ys, xs, object_img)
```

```
<Figure size 432x288 with 0 Axes>
```

In [9]:
```
%matplotlib notebook
import matplotlib.pyplot as plt
bottom_center = specify_bottom_center(background_img)
```

```
If it doesn't get you to the drawing mode, then rerun this function ag
ain. Also, make sure the object fill fit into the background image. Ot
herwise it will crash
```

In [10]:
```
%matplotlib inline
import matplotlib.pyplot as plt
cropped_object, object_mask = align_source(object_img, mask, background_
```



Part 2 Poisson Blending (50 pts)

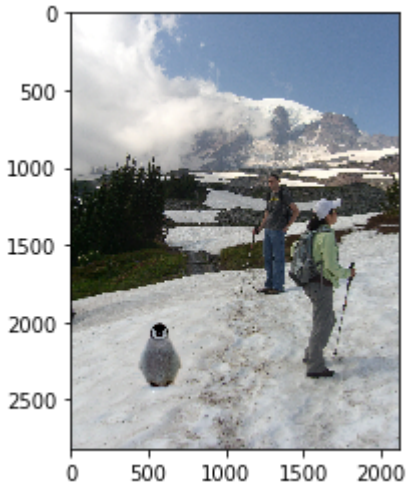
In [2]:
```
def hms(secs):
    hours = int(secs/3600.)
    remain = secs - hours*3600
    mins = int(remain/60.)
    remain = int(remain - mins*60)
    return (hours, mins, remain)
```

In [3]:
```
def poisson_blend(cropped_object, object_mask, background_img):
    """
    :param cropped_object: numpy.ndarray One you get from align_source
    :param object_mask: numpy.ndarray One you get from align_source
    :param background_img: numpy.ndarray
    """
    #TO DO
    #idx is the list of x, y coordinates that are in the mask
    idx = np.where(object_mask==1)
    idx = np.concatenate((idx[0].reshape(-1,1),idx[1].reshape(-1,1)),axi

    s=cropped_object
    t=background_img

    im_h, im_w, _ = t.shape
    im2var = np.arange(im_h * im_w).reshape(im_w, im_h).T
    num_v = im_h*im_w
    num_e = np.where(object_mask==1)[0].shape[0] * 5
    return_v = np.zeros(t.shape)

    for c in range(3):
        #A = csr_matrix((num_e,num_v))
        A = lil_matrix((num_e,num_v))
        b = np.zeros((num_e,))
        e=0
        tick = time.time()
        for x in range(im_w):
            for y in range(im_h):
                if object_mask[y][x]==1:
                    if x < im_w-1:
                        A[e,im2var[y][x+1]] = -1
                        A[e,im2var[y][x]] = 1
                        b[e] = s[y][x][c] - s[y][x+1][c]
                        e+=1
                    if y < im_h-1:
                        A[e,im2var[y+1][x]] = -1
                        A[e,im2var[y][x]] = 1
                        b[e] = s[y][x][c] - s[y+1][x][c]
                        e+=1
                    if x > 0:
                        A[e,im2var[y][x-1]] = -1
                        A[e,im2var[y][x]] = 1
                        b[e] = s[y][x][c] - s[y][x-1][c]
                        e+=1
                    if y > 0:
                        A[e,im2var[y-1][x]] = -1
                        A[e,im2var[y][x]] = 1
                        b[e] = s[y][x][c] - s[y-1][x][c]
                        e+=1
                    if object_mask[y][x+1]==0:
                        A[e,im2var[y][x]] = 1
                        b[e] = t[y][x+1][c] + s[y][x][c] - s[y][x+1][c]
                        e+=1
                    if object_mask[y][x-1]==0:
                        A[e,im2var[y][x]] = 1
                        b[e] = t[y][x-1][c] + s[y][x][c] - s[y][x-1][c]
```

```
                        e+=1
                    if object_mask[y+1][x]==0:
                        A[e,im2var[y][x]] = 1
                        b[e] = t[y+1][x][c] + s[y][x][c] - s[y+1][x][c]
                        e+=1
                    if object_mask[y-1][x]==0:
                        A[e,im2var[y][x]] = 1
                        b[e] = t[y-1][x][c] + s[y][x][c] - s[y-1][x][c]
                        e+=1
            tock = time.time()
            hr, mn, sc = hms(tock-tick)
            print(f'Equations for channel {c} took {hr} hours, {mn} minutes,

            tick = time.time()
            A=A.tocsr()
            A=csr_matrix(A)
            A=A[:e,:]
            b=b[:e]
            tock = time.time()
            hr, mn, sc = hms(tock-tick)
            print(f'Segmenting for channel {c} took {hr} hours, {mn} minutes

            tick = time.time()
            v = lsqr(A, b)
            tock = time.time()
            hr, mn, sc = hms(tock-tick)
            print(f'LSQR for channel {c} took {hr} hours, {mn} minutes, and


            return_v[:,:,c] = v[0].reshape((im_w, im_h)).T

        d3_mask = np.stack((object_mask,object_mask,object_mask),axis=2)
        return_v = background_img*(1-d3_mask) + return_v*d3_mask
        return_v[return_v > 1] = 1.
        return_v[return_v < 0] = 0.

        return return_v
```

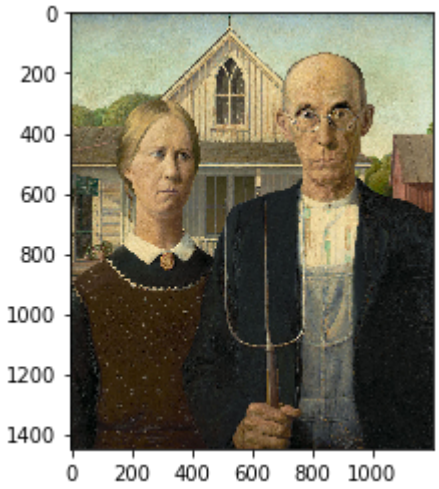
In [13]:
```
tickt = time.time()
im_blend = poisson_blend(cropped_object, object_mask, background_img)
if im_blend.any():
    %matplotlib inline
    import matplotlib.pyplot as plt
    plt.imshow(im_blend)
tockt = time.time()

h, m, s = hms(tockt-tickt)

print(f'Total time took {h} hours, {m} minutes, and {s} seconds')
```

```
Equations for channel 0 took 0 hours, 0 minutes, and 10 seconds
Segmenting for channel 0 took 0 hours, 0 minutes, and 0 seconds
(505756, 5947392)
(505756,)
5947392
505756
LSQR for channel 0 took 0 hours, 1 minutes, and 43 seconds
Equations for channel 1 took 0 hours, 0 minutes, and 10 seconds
Segmenting for channel 1 took 0 hours, 0 minutes, and 0 seconds
(505756, 5947392)
(505756,)
5947392
505756
LSQR for channel 1 took 0 hours, 1 minutes, and 42 seconds
Equations for channel 2 took 0 hours, 0 minutes, and 10 seconds
Segmenting for channel 2 took 0 hours, 0 minutes, and 0 seconds
(505756, 5947392)
(505756,)
5947392
505756
LSQR for channel 2 took 0 hours, 1 minutes, and 43 seconds
Total time took 0 hours, 5 minutes, and 43 seconds
```



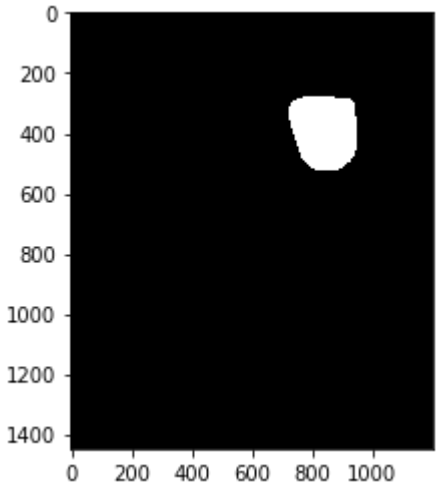
In [3]:
```
background_img = cv2.cvtColor(cv2.imread('samples/farmer.jpg'), cv2.COLO
plt.close()
plt.imshow(background_img)
```

Out[3]: <matplotlib.image.AxesImage at 0x7f40d80a6350>



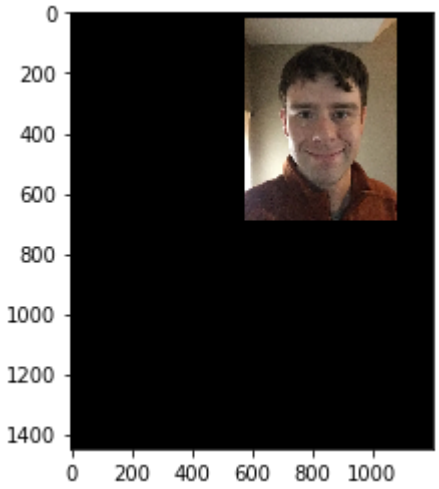
In [4]:
```
object_mask = cv2.cvtColor(cv2.imread('samples/face_mask.jpg'), cv2.COLO
object_mask = np.mean(object_mask,axis=2)
object_mask[object_mask >= 0.5] = 1.
object_mask[object_mask < 0.5] = 0.
plt.close()
plt.imshow(object_mask,cmap='gray')
```

Out[4]: <matplotlib.image.AxesImage at 0x7f40d7bbd810>



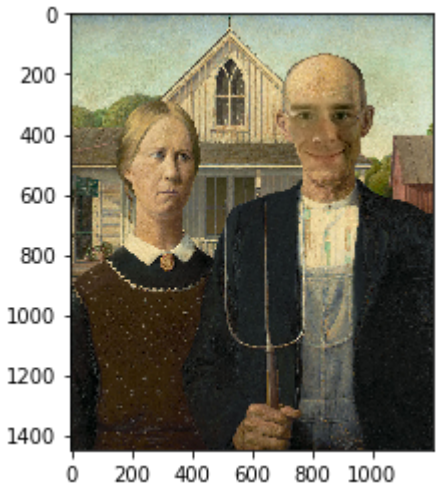
In [5]:
```
foreground_img = cv2.cvtColor(cv2.imread('samples/smile_cropped.jpg'), c
plt.close()
plt.imshow(foreground_img)
```

Out[5]: <matplotlib.image.AxesImage at 0x7f40d7b37390>



In [9]:
```
tickt = time.time()
im_blend = poisson_blend(foreground_img, object_mask, background_img)
if im_blend.any():
    %matplotlib inline
    import matplotlib.pyplot as plt
    plt.imshow(im_blend)
tockt = time.time()

h, m, s = hms(tockt-tickt)

print(f'Total time took {h} hours, {m} minutes, and {s} seconds')
```

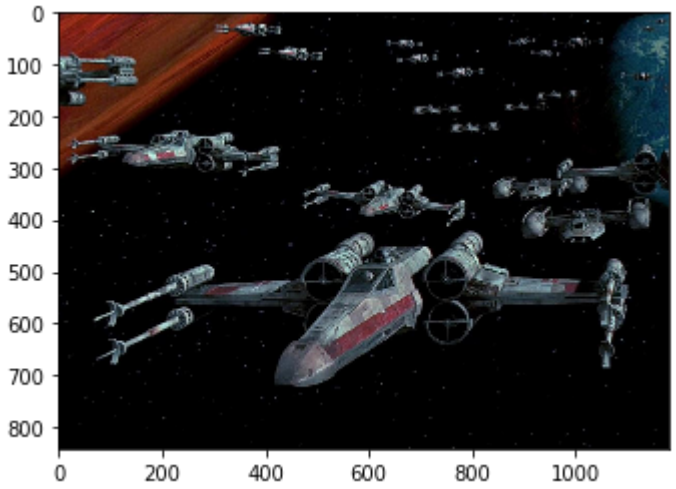
```
Equations for channel 0 took 0 hours, 0 minutes, and 1 seconds
Segmenting for channel 0 took 0 hours, 0 minutes, and 0 seconds
LSQR for channel 0 took 0 hours, 0 minutes, and 16 seconds
Equations for channel 1 took 0 hours, 0 minutes, and 1 seconds
Segmenting for channel 1 took 0 hours, 0 minutes, and 0 seconds
LSQR for channel 1 took 0 hours, 0 minutes, and 16 seconds
Equations for channel 2 took 0 hours, 0 minutes, and 2 seconds
Segmenting for channel 2 took 0 hours, 0 minutes, and 0 seconds
LSQR for channel 2 took 0 hours, 0 minutes, and 16 seconds
Total time took 0 hours, 0 minutes, and 57 seconds
```



In [10]:
```
plt.imsave('smile_farmer.jpg',im_blend)
```

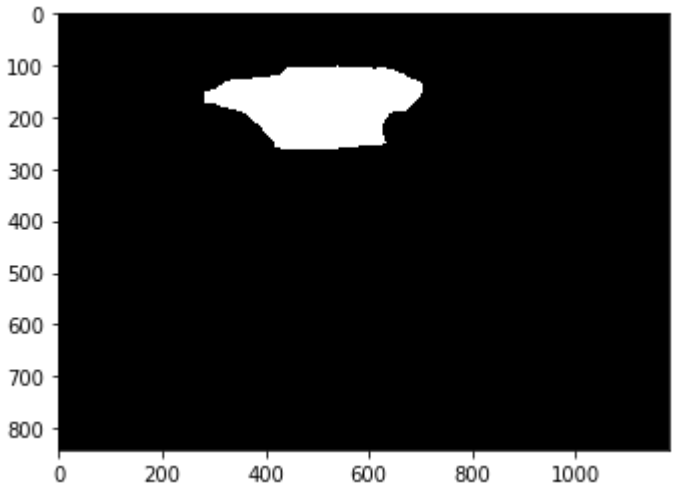
In [11]:
```
background_img = cv2.cvtColor(cv2.imread('samples/xwings.jpg'), cv2.COLO
plt.close()
plt.imshow(background_img)
```

Out[11]: <matplotlib.image.AxesImage at 0x7f408d423290>



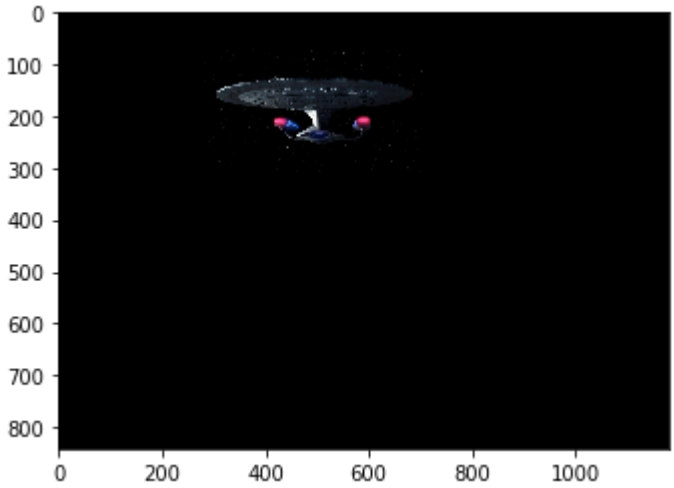
In [12]:
```
object_mask = cv2.cvtColor(cv2.imread('samples/enterprise_mask.jpg'), cv
object_mask = np.mean(object_mask,axis=2)
object_mask[object_mask >= 0.5] = 1.
object_mask[object_mask < 0.5] = 0.
plt.close()
plt.imshow(object_mask,cmap='gray')
```

Out[12]: <matplotlib.image.AxesImage at 0x7f408f6f5d90>



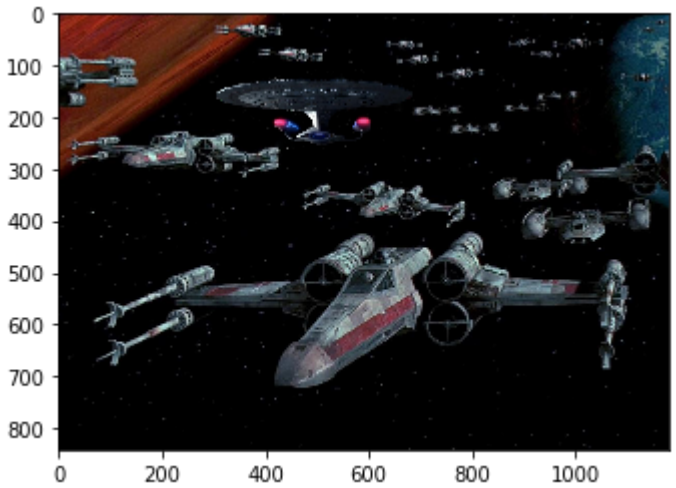
In [13]:
```
foreground_img = cv2.cvtColor(cv2.imread('samples/enterprise_cropped.jpg
plt.close()
plt.imshow(foreground_img)
```

Out[13]: <matplotlib.image.AxesImage at 0x7f408fd1a990>



In [14]:
```
tickt = time.time()
im_blend = poisson_blend(foreground_img, object_mask, background_img)
if im_blend.any():
    %matplotlib inline
    import matplotlib.pyplot as plt
    plt.imshow(im_blend)
tockt = time.time()

h, m, s = hms(tockt-tickt)

print(f'Total time took {h} hours, {m} minutes, and {s} seconds')
```

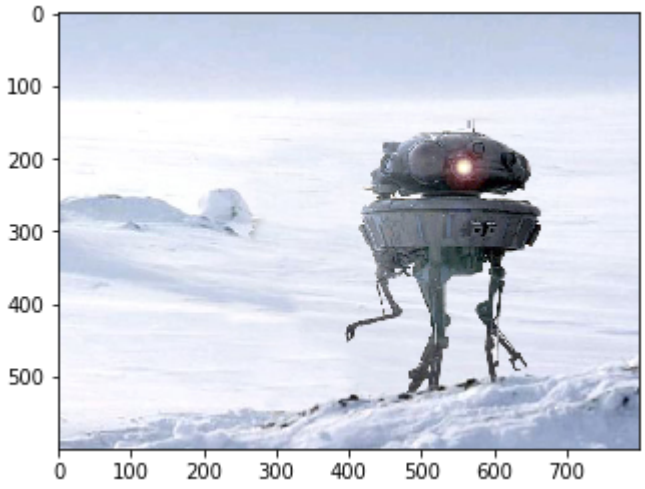
```
Equations for channel 0 took 0 hours, 0 minutes, and 1 seconds
Segmenting for channel 0 took 0 hours, 0 minutes, and 0 seconds
LSQR for channel 0 took 0 hours, 0 minutes, and 8 seconds
Equations for channel 1 took 0 hours, 0 minutes, and 1 seconds
Segmenting for channel 1 took 0 hours, 0 minutes, and 0 seconds
LSQR for channel 1 took 0 hours, 0 minutes, and 8 seconds
Equations for channel 2 took 0 hours, 0 minutes, and 1 seconds
Segmenting for channel 2 took 0 hours, 0 minutes, and 0 seconds
LSQR for channel 2 took 0 hours, 0 minutes, and 8 seconds
Total time took 0 hours, 0 minutes, and 32 seconds
```



In [15]:
```
plt.imsave('enterprise_xwings.jpg',im_blend)
```

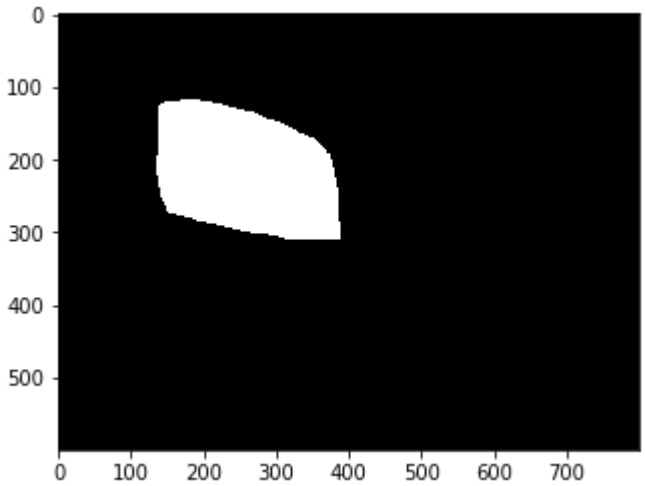
In [4]:
```
background_img = cv2.cvtColor(cv2.imread('samples/probe.jpg'), cv2.COLOR
plt.close()
plt.imshow(background_img)
```

Out[4]: <matplotlib.image.AxesImage at 0x7f80063d1410>



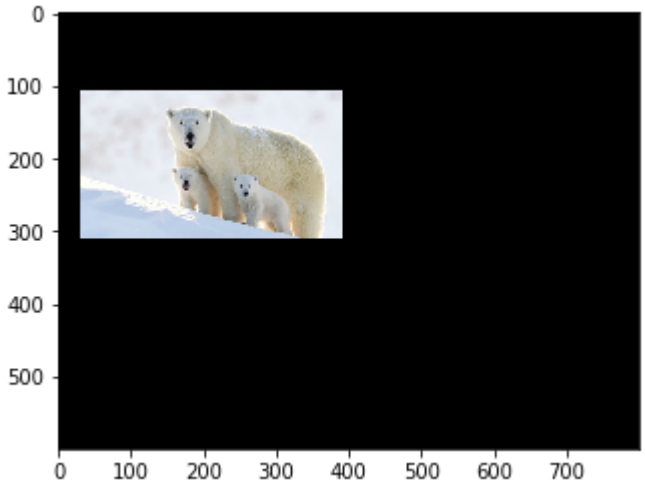
In [5]:
```
object_mask = cv2.cvtColor(cv2.imread('samples/polar_bear_mask_fail.jpg'
object_mask = np.mean(object_mask,axis=2)
object_mask[object_mask >= 0.5] = 1.
object_mask[object_mask < 0.5] = 0.
plt.close()
plt.imshow(object_mask,cmap='gray')
```

Out[5]: <matplotlib.image.AxesImage at 0x7f7ff4420810>



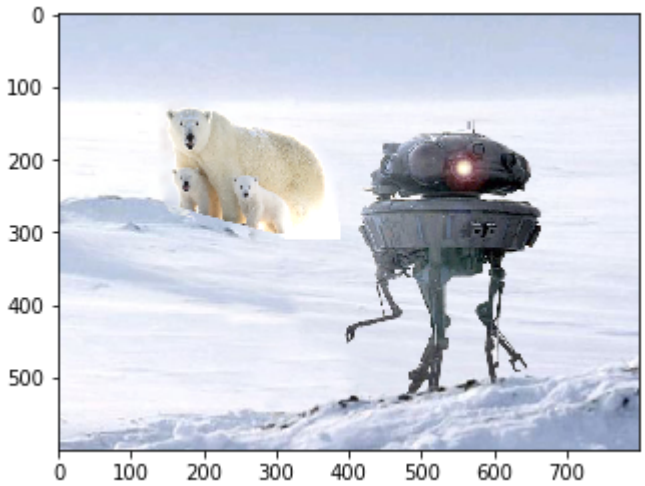
In [6]:
```
foreground_img = cv2.cvtColor(cv2.imread('samples/polar_bear_cropped.jpg
plt.close()
plt.imshow(foreground_img)
```

Out[6]: <matplotlib.image.AxesImage at 0x7f7ff4415390>



In [7]:
```
tickt = time.time()
im_blend = poisson_blend(foreground_img, object_mask, background_img)
if im_blend.any():
    %matplotlib inline
    import matplotlib.pyplot as plt
    plt.imshow(im_blend)
tockt = time.time()

h, m, s = hms(tockt-tickt)

print(f'Total time took {h} hours, {m} minutes, and {s} seconds')
```

```
Equations for channel 0 took 0 hours, 0 minutes, and 1 seconds
Segmenting for channel 0 took 0 hours, 0 minutes, and 0 seconds
LSQR for channel 0 took 0 hours, 0 minutes, and 3 seconds
Equations for channel 1 took 0 hours, 0 minutes, and 1 seconds
Segmenting for channel 1 took 0 hours, 0 minutes, and 0 seconds
LSQR for channel 1 took 0 hours, 0 minutes, and 3 seconds
Equations for channel 2 took 0 hours, 0 minutes, and 1 seconds
Segmenting for channel 2 took 0 hours, 0 minutes, and 0 seconds
LSQR for channel 2 took 0 hours, 0 minutes, and 3 seconds
Total time took 0 hours, 0 minutes, and 16 seconds
```



In [8]:
```
plt.imsave('polar_droid_fail.jpg',im_blend)
```

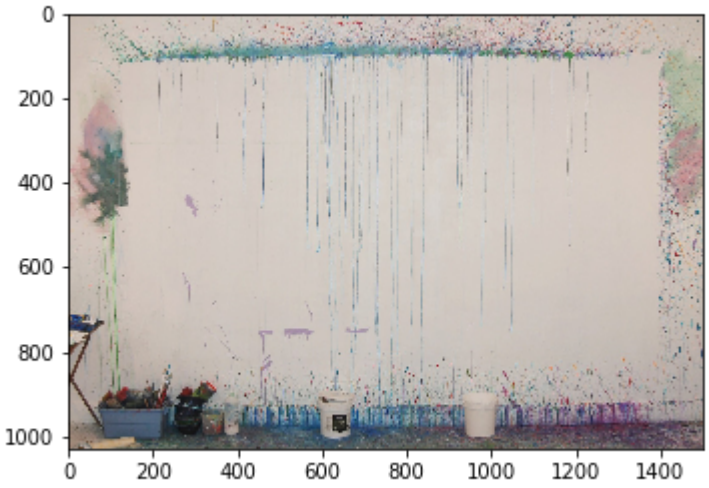
In [ ]:

In [ ]:

In [ ]:

Part 3 Mixed Gradients (20 pts)

In [16]:
```
background_img = cv2.cvtColor(cv2.imread('samples/street.jpg'), cv2.COLO
plt.figure()
plt.imshow(background_img)
```



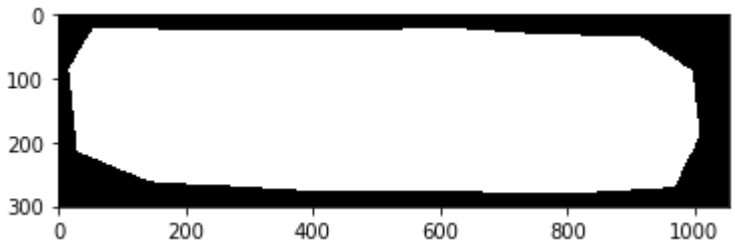
Out[16]:
```
<matplotlib.image.AxesImage at 0x7f7ff414f410>
```

In [13]:
```
object_img = cv2.cvtColor(cv2.imread('samples/we_the_people2.jpg'), cv2.
import matplotlib.pyplot as plt
%matplotlib notebook
mask_coords = specify_mask(object_img)
```

```
If it doesn't get you to the drawing mode, then rerun this function ag
ain.
```

In [14]:
```
xs = mask_coords[0]
ys = mask_coords[1]
%matplotlib inline
import matplotlib.pyplot as plt
plt.figure()
mask = get_mask(ys, xs, object_img)
```

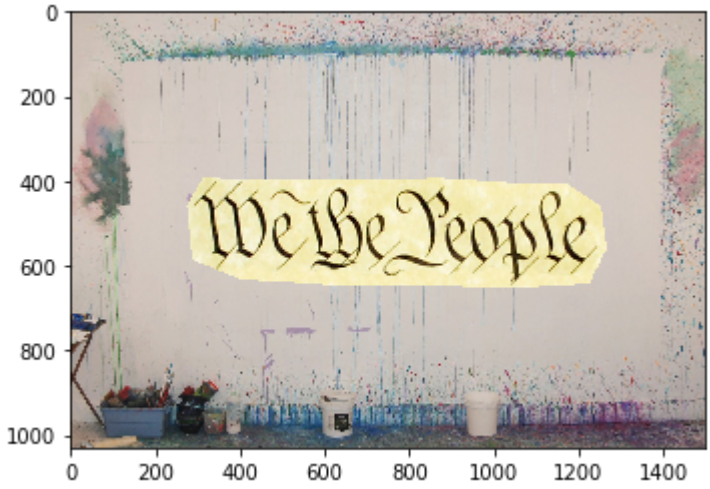
```
<Figure size 432x288 with 0 Axes>
```



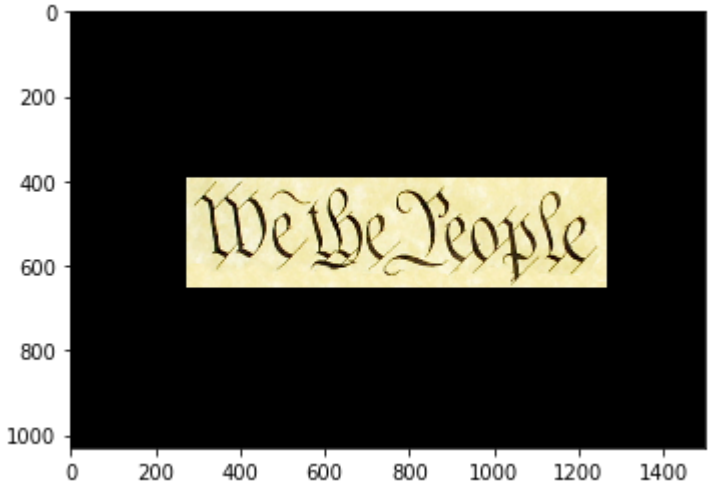
In [17]:
```
%matplotlib notebook
import matplotlib.pyplot as plt
bottom_center = specify_bottom_center(background_img)
```

```
If it doesn't get you to the drawing mode, then rerun this function ag
ain. Also, make sure the object fill fit into the background image. Ot
herwise it will crash
```

In [18]:
```
%matplotlib inline
import matplotlib.pyplot as plt
cropped_object, object_mask = align_source(object_img, mask, background_
```



In [19]:
```
plt.close()
plt.imshow(cropped_object)
plt.imsave('samples/we_the_people_cropped.jpg',cropped_object)
```



In [20]:
```
def mix_blend(cropped_object, object_mask, background_img):
    """
    :param cropped_object: numpy.ndarray One you get from align_source
    :param object_mask: numpy.ndarray One you get from align_source
    :param background_img: numpy.ndarray
    """
    idx = np.where(object_mask==1)
    idx = np.concatenate((idx[0].reshape(-1,1),idx[1].reshape(-1,1)),axi

    s=cropped_object
    t=background_img

    im_h, im_w, _ = t.shape
    im2var = np.arange(im_h * im_w).reshape(im_w, im_h).T
    num_v = im_h*im_w
    num_e = np.where(object_mask==1)[0].shape[0] * 5
    return_v = np.zeros(t.shape)

    for c in range(3):
        #A = csr_matrix((num_e,num_v))
        A = lil_matrix((num_e,num_v))
        b = np.zeros((num_e,))
        e=0
        tick = time.time()
        for x in range(im_w):
            for y in range(im_h):
                if object_mask[y][x]==1:
                    if x < im_w-1:
                        si = s[y][x][c] - s[y][x+1][c]
                        ti = t[y][x][c] - t[y][x+1][c]
                        if np.absolute(si) > np.absolute(ti):
                            d = si
                        else:
                            d = ti

                        A[e,im2var[y][x+1]] = -1
                        A[e,im2var[y][x]] = 1
                        b[e] = d
                        e+=1
                    if y < im_h-1:
                        si = s[y][x][c] - s[y+1][x][c]
                        ti = t[y][x][c] - t[y+1][x][c]
                        if np.absolute(si) > np.absolute(ti):
                            d = si
                        else:
                            d = ti

                        A[e,im2var[y+1][x]] = -1
                        A[e,im2var[y][x]] = 1
                        b[e] = d
                        e+=1
                    if x > 0:
                        si = s[y][x][c] - s[y][x-1][c]
                        ti = t[y][x][c] - t[y][x-1][c]
                        if np.absolute(si) > np.absolute(ti):
                            d = si
```

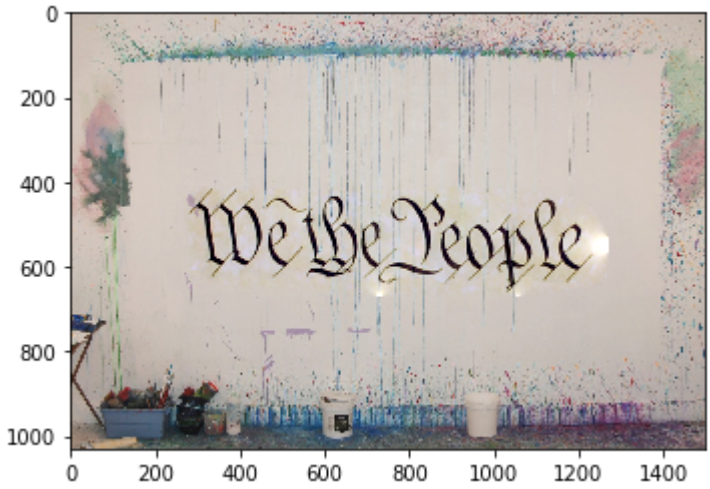
```
            else:
                d = ti

            A[e,im2var[y][x-1]] = -1
            A[e,im2var[y][x]] = 1
            b[e] = d
            e+=1
        if y > 0:
            si = s[y][x][c] - s[y-1][x][c]
            ti = t[y][x][c] - t[y-1][x][c]
            if np.absolute(si) > np.absolute(ti):
                d = si
            else:
                d = ti

            A[e,im2var[y-1][x]] = -1
            A[e,im2var[y][x]] = 1
            b[e] = d
            e+=1
        if object_mask[y][x+1]==0:
            si = s[y][x][c] - s[y][x+1][c]
            ti = t[y][x][c] - t[y][x+1][c]
            if np.absolute(si) > np.absolute(ti):
                d = si
            else:
                d = ti

            A[e,im2var[y][x]] = 1
            b[e] = t[y][x+1][c] + d
            e+=1
        if object_mask[y][x-1]==0:
            si = s[y][x][c] - s[y][x-1][c]
            ti = t[y][x][c] - t[y][x-1][c]
            if np.absolute(si) > np.absolute(ti):
                d = si
            else:
                d = ti

            A[e,im2var[y][x]] = 1
            b[e] = t[y][x-1][c] + d
            e+=1
        if object_mask[y+1][x]==0:
            si = s[y][x][c] - s[y+1][x][c]
            ti = t[y][x][c] - t[y+1][x][c]
            if np.absolute(si) > np.absolute(ti):
                d = si
            else:
                d = ti

            A[e,im2var[y][x]] = 1
            b[e] = t[y+1][x][c] + d
            e+=1
        if object_mask[y-1][x]==0:
            si = s[y][x][c] - s[y-1][x][c]
            ti = t[y][x][c] - t[y-1][x][c]
            if np.absolute(si) > np.absolute(ti):
                d = si
```

```
                    else:
                        d = ti

                    A[e,im2var[y][x]] = 1
                    b[e] = t[y-1][x][c] + s[y][x][c] - s[y-1][x][c]
                    e+=1
        tock = time.time()
        hr, mn, sc = hms(tock-tick)
        print(f'Equations for channel {c} took {hr} hours, {mn} minutes,

        tick = time.time()
        A=A.tocsr()
        A=A[:e,:]
        b=b[:e]
        tock = time.time()
        hr, mn, sc = hms(tock-tick)
        print(f'Segmenting for channel {c} took {hr} hours, {mn} minutes

        tick = time.time()
        v = lsqr(A, b)
        tock = time.time()
        hr, mn, sc = hms(tock-tick)
        print(f'LSQR for channel {c} took {hr} hours, {mn} minutes, and


        return_v[:,:,c] = v[0].reshape((im_w, im_h)).T

    d3_mask = np.stack((object_mask,object_mask,object_mask),axis=2)
    return_v = background_img*(1-d3_mask) + return_v*d3_mask
    return_v[return_v > 1] = 1.
    return_v[return_v < 0] = 0.

    return return_v
```

In [ ]:

In [40]:
```
im_mix = mix_blend(cropped_object, object_mask, background_img)
if im_mix.any():
    %matplotlib inline
    import matplotlib.pyplot as plt
    plt.imshow(im_mix)
```

```
Equations for channel 0 took 0 hours, 0 minutes, and 12 seconds
Segmenting for channel 0 took 0 hours, 0 minutes, and 0 seconds
LSQR for channel 0 took 0 hours, 0 minutes, and 38 seconds
Equations for channel 1 took 0 hours, 0 minutes, and 12 seconds
Segmenting for channel 1 took 0 hours, 0 minutes, and 0 seconds
LSQR for channel 1 took 0 hours, 0 minutes, and 38 seconds
Equations for channel 2 took 0 hours, 0 minutes, and 12 seconds
Segmenting for channel 2 took 0 hours, 0 minutes, and 0 seconds
LSQR for channel 2 took 0 hours, 0 minutes, and 37 seconds
```



In [41]:
```
plt.imsave('we_the_people1.jpg',im_mix)
```

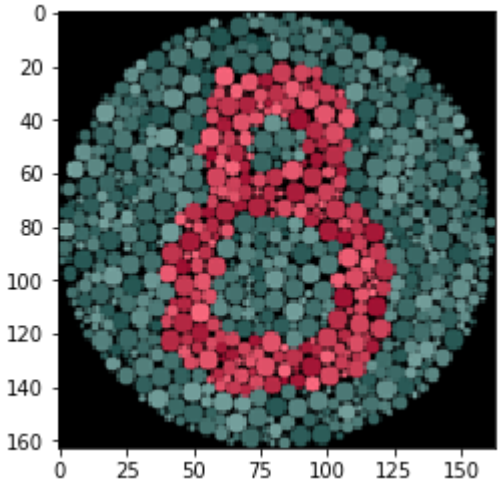
Bells & Whistles (Extra Points)

Color2Gray (20 pts)

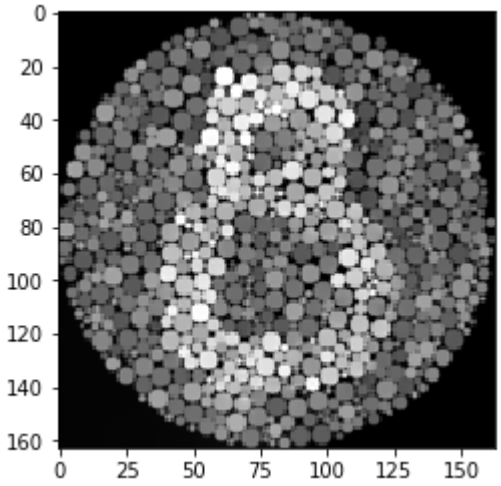
In [141]:
```
def color2gray(clr_img):
    """
    The implementation for gradient domain processing is not complicated
    1. minimize (v(x+1,y)-v(x,y) - (s(x+1,y)-s(x,y)))^2
    2. minimize (v(x,y+1)-v(x,y) - (s(x,y+1)-s(x,y)))^2
    Note that these could be solved while adding any constant value to v
    3. minimize (v(1,1)-s(1,1))^2

    :param toy_img: numpy.ndarray
    """
    im=clr_img
    im_h, im_w, im_c = im.shape
    im2var = np.arange(im_h * im_w).reshape(im_w, im_h).T
    num_v = (im_h)*(im_w)
    num_e = im_h*(im_w-1) + im_w*(im_h-1) + 1
    #A = np.zeros((num_e,num_v))
    A = lil_matrix((num_e,num_v))
    b = np.zeros((num_e,))
    e=0
    for x in range(im_w):
        for y in range(im_h):
            if x < im_w-1:
                d = im[y,x+1,:] - im[y,x,:]
                d = max(d.min(), d.max(), key=abs)
                A[e,im2var[y][x+1]] = 1
                A[e,im2var[y][x]] = -1
                b[e] = d
                e+=1
            if y < im_h-1:
                d = im[y+1,x,:] - im[y,x,:]
                d = max(d.min(), d.max(), key=abs)
                A[e,im2var[y+1][x]] = 1
                A[e,im2var[y][x]] = -1
                b[e] = d
                e+=1

    A[e,im2var[0][0]] = 1
    b[e] = np.mean(im[0,0,:])
    A=A.tocsr()
    v = lsqr(A, b)
    v[0][v[0] > 1] = 1.
    v[0][v[0] < 0] = 0.
    return v[0].reshape((im_w, im_h)).T
```

In [143]:
```
clr_img = cv2.cvtColor(cv2.imread('samples/colorBlind8.png'), cv2.COLOR_
plt.imshow(clr_img)
```

Out[143]:
```
<matplotlib.image.AxesImage at 0x7f26a8ddf790>
```

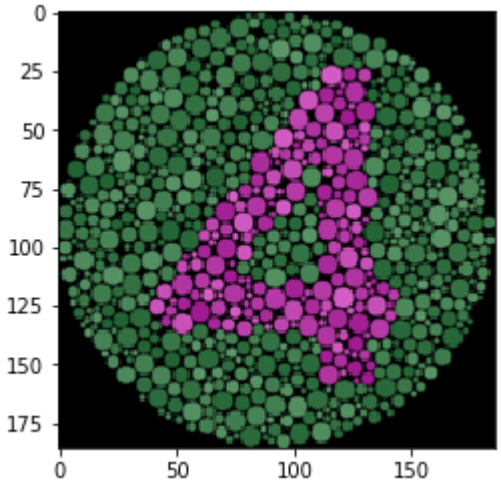


In [144]:
```
gray_img = color2gray(clr_img)
plt.close()
plt.imshow(gray_img,cmap='gray')
im_save = np.stack((gray_img,gray_img,gray_img),axis=2)
plt.imsave('gray_colorblind8.jpg',im_save)
```

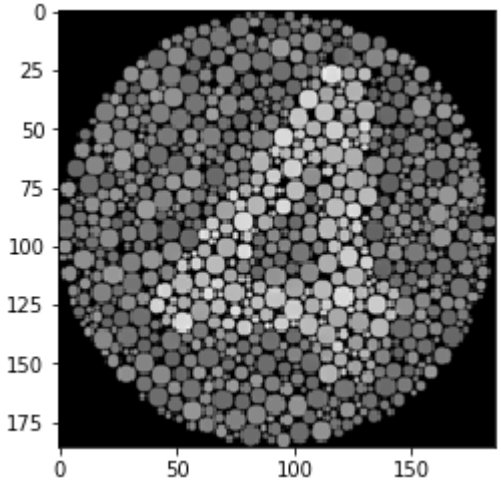


In [127]:
```
clr_img = cv2.cvtColor(cv2.imread('samples/colorBlind4.png'), cv2.COLOR_
plt.close()
plt.imshow(clr_img)
```

Out[127]:
```
<matplotlib.image.AxesImage at 0x7f26c425cd90>
```



In [142]:
```
gray_img = color2gray(clr_img)
plt.close()
plt.imshow(gray_img,cmap='gray')
im_save = np.stack((gray_img,gray_img,gray_img),axis=2)
plt.imsave('gray_colorblind4.jpg',im_save)
```



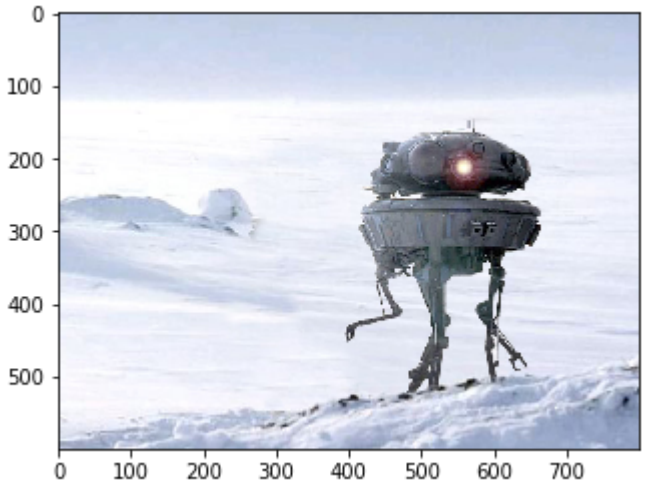
Laplacian pyramid blending (20 pts)

In [29]:
```
def blur_img(img,kernel_size=None):
    #sigma_low = 1./(2*np.pi*cutoff_low)
    kernel = cv2.getGaussianKernel(kernel_size,-1)
    kernel = np.dot(kernel,kernel.T)
    blur_img = cv2.filter2D(img, -1, kernel)


    #if kernel_size is None:
    #    kernel_size = int(min(img.shape[0],img.shape[1])/15)
    #if kernel_size % 2 == 0:
    #    kernel_size += 1
    #blur_img = cv2.GaussianBlur(img,(kernel_size,kernel_size),cv2.BORDE




    return blur_img
```

In [55]:
```
def laplacian_blend(img1, img2, mask):
    L10 = img1 - blur_img(img1,kernel_size=25)
    L20 = img2 - blur_img(img2,kernel_size=25)
    mask_L0 = blur_img(mask,kernel_size=5)
    mask_L0 = np.stack((mask_L0,mask_L0,mask_L0),axis=2)
    L0 = L20 * mask_L0 + L10 * (1-mask_L0)
    L11 = blur_img(img1,kernel_size=25)
    L21 = blur_img(img2,kernel_size=25)
    mask_L1 = blur_img(mask,kernel_size=25)
    mask_L1 = np.stack((mask_L1,mask_L1,mask_L1),axis=2)
    L1 = L21 * mask_L1 + L11 * (1-mask_L1)
    lap_blend = L1 + L0
    lap_blend[lap_blend > 1] = 1.
    lap_blend[lap_blend < 0] = 0.
    return lap_blend
```

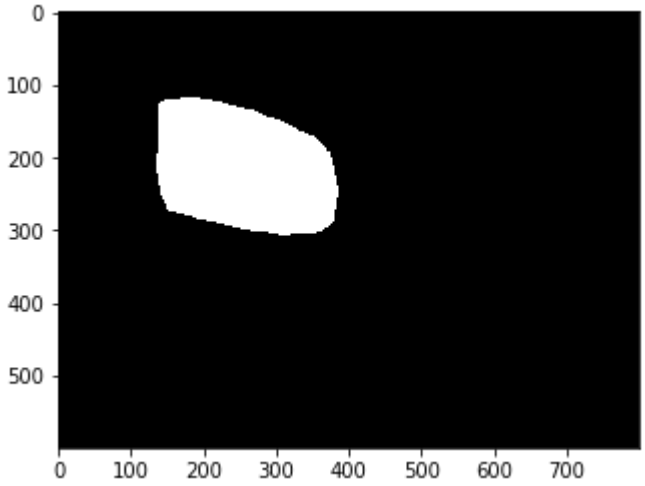
In [41]:
```
background_img = cv2.cvtColor(cv2.imread('samples/probe.jpg'), cv2.COLOR
plt.close()
plt.imshow(background_img)
```

Out[41]: <matplotlib.image.AxesImage at 0x7fe734316690>



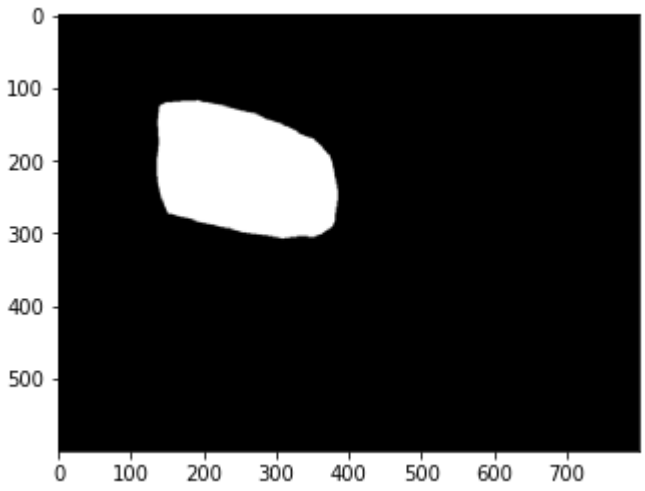
In [2]:
```
object_mask = cv2.cvtColor(cv2.imread('samples/polar_bear_mask.jpg'), cv
object_mask = np.mean(object_mask,axis=2)
object_mask[object_mask >= 0.5] = 1.
object_mask[object_mask < 0.5] = 0.
plt.close()
plt.imshow(object_mask,cmap='gray')
```

Out[2]: <matplotlib.image.AxesImage at 0x7fe75d929e10>



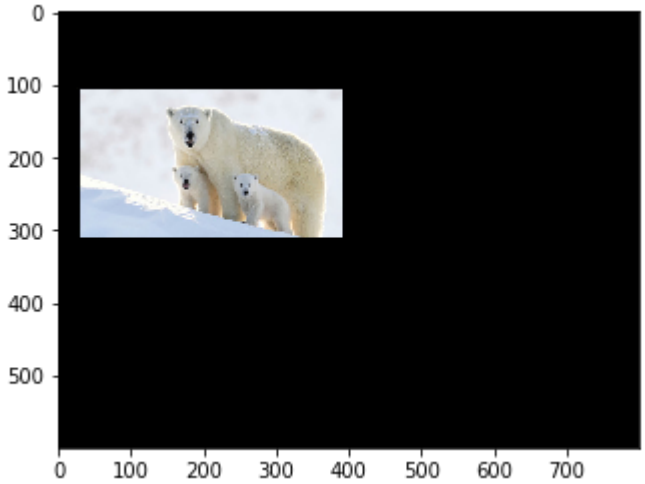
In [39]:
```
mask_l1 = blur_img(object_mask,kernel_size=5)
plt.close()
plt.imshow(mask_l1,cmap='gray')
```

Out[39]: <matplotlib.image.AxesImage at 0x7fe7343c8ed0>

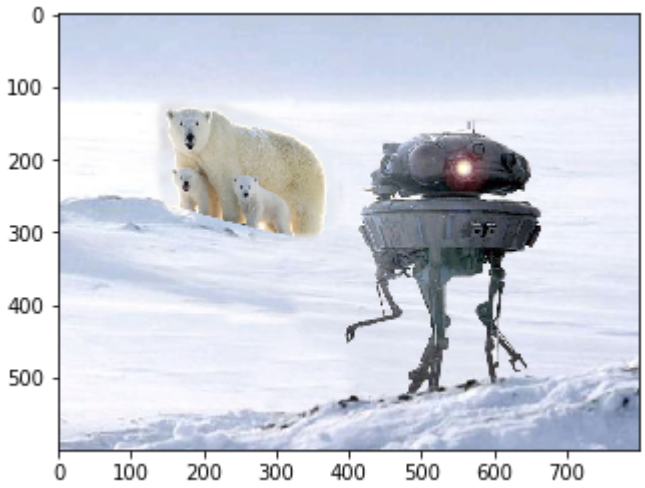


In [43]:
```
foreground_img = cv2.cvtColor(cv2.imread('samples/polar_bear_cropped.jpg
plt.close()
plt.imshow(foreground_img)
```

Out[43]: <matplotlib.image.AxesImage at 0x7fe734273d90>



In [57]:
```
lap_blend = laplacian_blend(background_img, foreground_img, object_mask)
plt.close()
plt.imshow(lap_blend)
plt.imsave('laplacian_blend.jpg',lap_blend)
```



In [ ]:

In [ ]:

In [ ]:

In [ ]:

More gradient domain processing (up to 20 pts)

In [ ]: