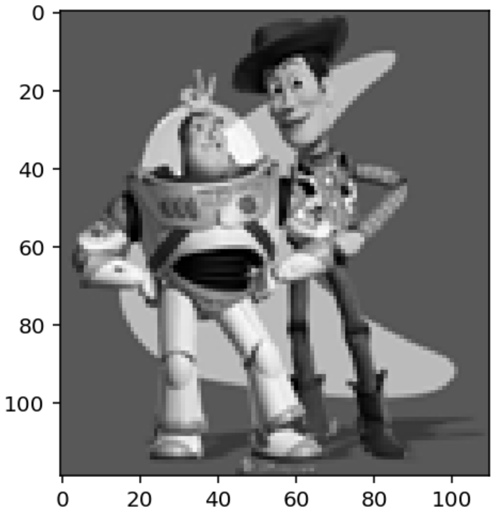
```
In [2]: import cv2
        import numpy as np
        import scipy as sp
        import scipy.sparse
        import scipy.sparse.linalg
        %matplotlib inline
        import matplotlib.pyplot as plt
        import matplotlib
        from utils import *
        import os
```

```
In [257]: toy_img = cv2.imread('samples/toy_problem.png').astype(np.float64) / 255.
          plt.imshow(toy_img)
```



```
Out[257]: <matplotlib.image.AxesImage at 0xc4250ad30>
```

Part 1 Toy Problem (20 pts)

In [258]:

```
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_h, im_w,_ = toy_img.shape
    im2var = np.arange(im_h * im_w).reshape(im_h, im_w)
    A = np.zeros((im_h*(im_w-1) + (im_h-1)*im_w + 1, im_h*im_w))
    b = np.zeros(im_h*(im_w-1) + (im_h-1)*im_w + 1)

    e = 0
    for y in range(im_h):
        for x in range(im_w-1):
            A[e][im2var[y][x+1]] = 1
            A[e][im2var[y][x]] = -1
            b[e] = toy_img[y][x+1][0] - toy_img[y][x][0]
            e += 1

    for y in range(im_h-1):
        for x in range(im_w):
            A[e][im2var[y+1][x]] = 1
            A[e][im2var[y][x]] = -1
            b[e] = toy_img[y+1][x][0] - toy_img[y][x][0]
            e += 1

    A[e][im2var[0][0]] = 1
    b[e] = toy_img[0][0][0]

    A = sp.sparse.csr_matrix(A)

    v = sp.sparse.linalg.lsqr(A, b, atol=10**-14, btol=10**-14)

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

In [259]:

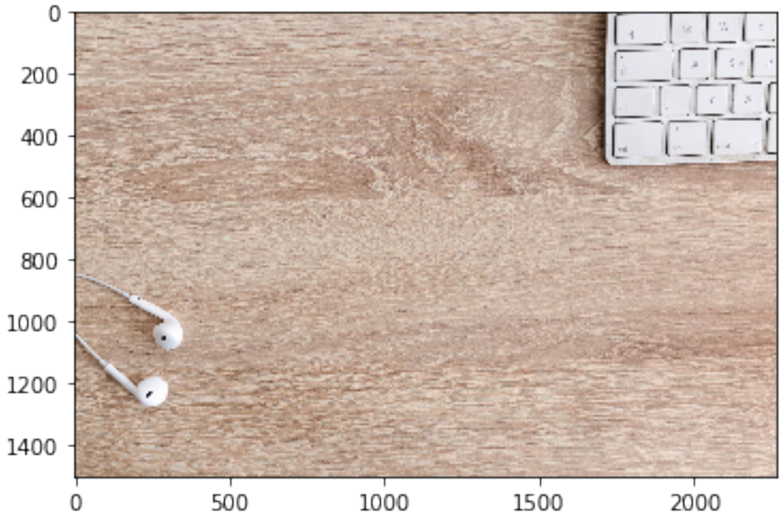
```
im_out = toy_reconstruct(toy_img)
print("Error is: ", np.sqrt(((im_out - toy_img[:,:,0])**2).sum()))
```

```
Error is:  2.0943120207502896e-10
```

Preparation

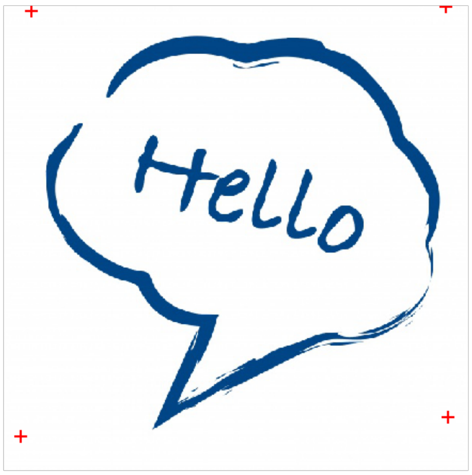
In [244]:
```
background_img = cv2.imread('samples/3.jpeg')
background_img = cv2.cvtColor(background_img, cv2.COLOR_BGR2RGB).astype('
plt.figure()
plt.imshow(background_img)
```

Out[244]:
```
<matplotlib.image.AxesImage at 0xc2f96aa90>
```



In [260]:
```
object_img = cv2.imread('samples/4.jpg')
object_img = cv2.cvtColor(object_img, cv2.COLOR_BGR2RGB).astype('double')
import matplotlib.pyplot as plt
%matplotlib notebook
mask_coords = specify_mask(object_img)
```

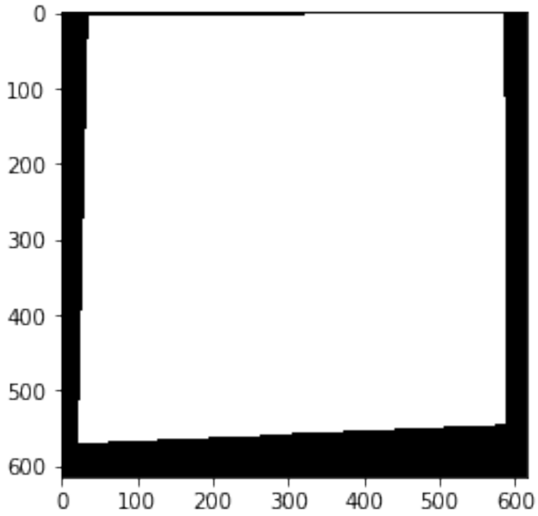
```
If it doesn't get you to the drawing mode, then rerun this function ag
ain.
```



In [261]:

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

```
<matplotlib.figure.Figure at 0xc2f99aac8>
```

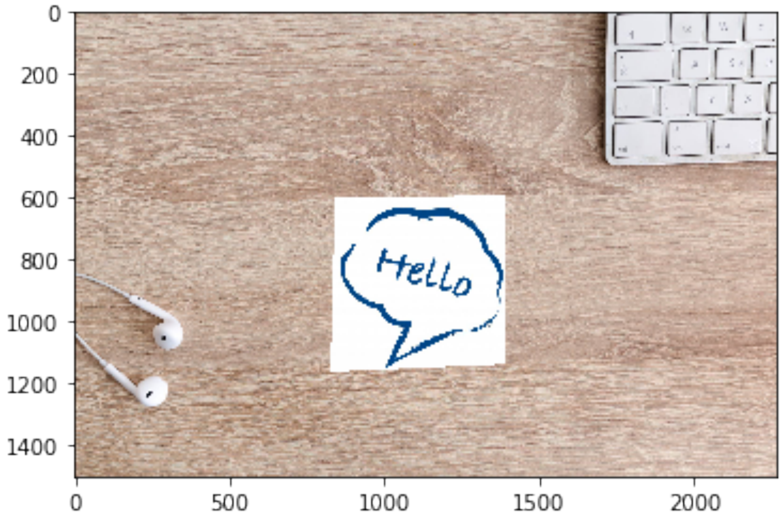


In [268]:
```
%matplotlib notebook
import matplotlib.pyplot as plt
bottom_center = specify_bottom_center(background_img)
```

```
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 [269]: %matplotlib inline
          import matplotlib.pyplot as plt
          cropped_object, object_mask = align_source(object_img, mask, background_i
          print(object_mask)
```

```
[[False False False ... False False False]
 [False False False ... False False False]
 [False False False ... False False False]
 ...
 [False False False ... False False False]
 [False False False ... False False False]
 [False False False ... False False False]]
```



Part 2 Poisson Blending (50 pts)

```
In [112]: def neighbour(x, y):
              return [(x+1, y), (x-1, y), (x, y+1), (x, y-1)]
```

```
In [219]: 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
              mask2 = np.zeros(background_img.shape)
              for i in range(3):
                  mask2[:, :, i] = object_mask

              ys, xs = np.where(object_mask==1)
              values = list(zip(ys, xs))
              val_dict = dict(zip(values, range(len(values))))
```

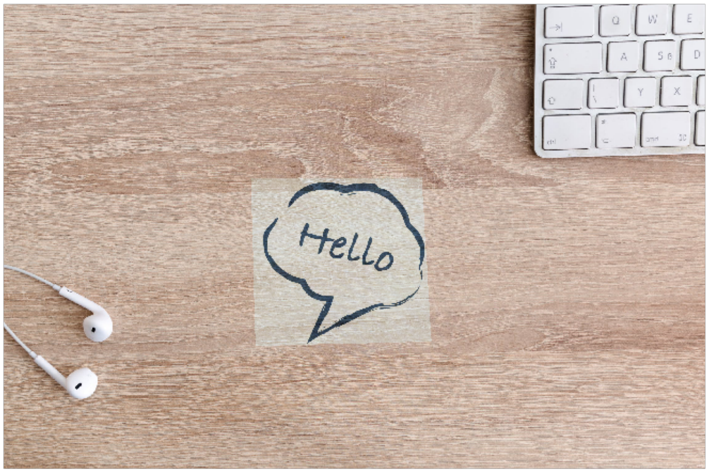
```
    vs = np.zeros(background_img.shape)
    A = sp.sparse.lil_matrix((len(values)*4, len(values)))

    e = 0

    for index in values:
        for n in neighbour(index[0], index[1]):
            A[e, val_dict[index]] = 1
            if n in val_dict:
                A[e, val_dict[n]] = -1
            e += 1

    A = sp.sparse.csr_matrix(A)


    for i in range(3):
        b = np.zeros(len(values)*4)
        e = 0

        for index in values:
            for n in neighbour(index[0], index[1]):
                b[e] = cropped_object[index[0]][index[1]][i]-cropped_obje
                if n not in val_dict:
                    b[e] += background_img[n[0]][n[1]][i]
                e += 1

        v = sp.sparse.linalg.lsqr(A, b, atol=10**-14, btol=10**-14)[0]

        v[v<0] = 0
        v[v>1] = 1


        for key, val in val_dict.items():
            vs[key[0]][key[1]][i] = v[val]

    return vs + (background_img)*(1-mask2)
```

In [220]:

```
%matplotlib notebook
im_blend = poisson_blend(cropped_object, object_mask, background_img)
```

In [221]:

```
plt.axis('off')
plt.imshow(im_blend)
```



Out[221]:

```
<matplotlib.image.AxesImage at 0xc1b600da0>
```

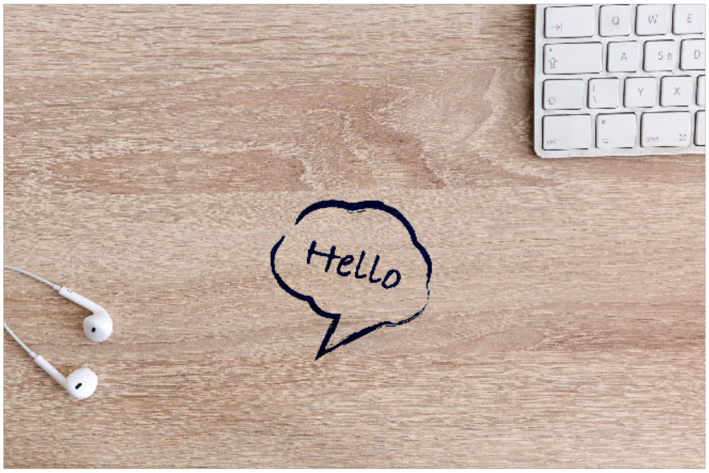
Part 3 Mixed Gradients (20 pts)

In [270]:

```
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
    """
    #TO DO
    mask2 = np.zeros(background_img.shape)
    for i in range(3):
        mask2[:, :, i] = object_mask

    ys, xs = np.where(object_mask==1)
    values = list(zip(ys, xs))
    val_dict = dict(zip(values, range(len(values))))
    vs = np.zeros(background_img.shape)
    A = sp.sparse.lil_matrix((len(values)*4, len(values)))

    e = 0

    for index in values:
        for n in neighbour(index[0], index[1]):
            A[e, val_dict[index]] = 1
            if n in val_dict:
                A[e, val_dict[n]] = -1
            e += 1

    A = sp.sparse.csr_matrix(A)


    for i in range(3):
        b = np.zeros(len(values)*4)
        e = 0

        for ind in values:
            for n in neighbour(ind[0], ind[1]):
                sg = cropped_object[ind[0]][ind[1]][i]-cropped_object[n[0
                tg = background_img[ind[0]][ind[1]][i]-background_img[n[0
                if abs(sg) > abs(tg):
                    b[e] = sg
                else:
                    b[e] = tg
                if n not in val_dict:
                    b[e] += background_img[n[0]][n[1]][i]
                e += 1

        v = sp.sparse.linalg.lsqr(A, b,atol=10**-14, btol=10**-14)[0]
        v[v<0] = 0
        v[v>1] = 1

        for key, val in val_dict.items():
            vs[key[0]][key[1]][i] = v[val]

    return vs + (background_img)*(1-mask2)
```

In [272]:

```
im_mix = mix_blend(cropped_object, object_mask, background_img)

%matplotlib notebook
plt.axis('off')
plt.imshow(im_mix)
```



```
Out[272]: <matplotlib.image.AxesImage at 0xc1b60cf28>
```

Bells & Whistles (Extra Points)

Color2Gray (20 pts)

In [ ]:

```
def color2gray(img):
    pass
```

Laplacian pyramid blending (20 pts)

In [ ]:

```
def laplacian_blend(img1, img2):
    pass
```

More gradient domain processing (up to 20 pts)

In [ ]: