Question 1 (12 marks)

To detect corners in an image, the Harris corner detector can be used. Figure 1 shows an image I(x,y), where x is horizontal axis (column numbers) and y is vertical axis (row numbers).

y -axis \ *x-axis*	*0*	*1*	*2*	*3*	*4*	*5*
0	**100**	**100**	**100**	**100**	**100**	**100**
1	**100**	**100**	**100**	**100**	**100**	**100**
2	**100**	**100**	**200**	**200**	**100**	**100**
3	**100**	**100**	**200**	**200**	**100**	**100**
4	**100**	**100**	**200**	**200**	**100**	**100**
5	**100**	**100**	**100**	**100**	**100**	**100**

Figure 1: Image I(x,y)

(a) Using the operators, $\mathbf{S_x = [\ -1\ \ 0\ \ +1]}$ and $\mathbf{S_y = [\ -1\ \ 0\ \ +1]^T}$, compute the horizontal gradients $\mathbf{I_x}$ and the vertical gradients $\mathbf{I_y}$ of the image I(x,y).

[2 marks]

(b) Determine the matrix H, at the pixel positions (1, 1) and (1, 3). The window size used in 3 x 3.

[4 marks]

(c) Compute the following corner response function at the two pixel positions (1, 1) and (1, 3):

$$R = \det(H) - k(\text{trace}(H))^2$$

Where $k=0.05$, and the window size used is 3 x 3.

[4 marks]

(d) Discuss how you use R to detect corners, and discuss your computed values of R.

[2 marks]

Question 2 (8 marks)

For a given image patch in two consecutive frames of an image sequence, I_x, I_y and I_t are given by:

	Pixel p_1	**Pixel p_2**
I_x =	[10.75	17.50]
I_y =	[20.25	17.00]
I_t =	[11.25	06.00]

The brightness constancy constraint that is utilized in optical flow computation can be written as follows:

$$(u\ v)^\top \cdot \nabla I + \frac{dI}{dt} = 0$$

and it relates the flow to the spatial and temporal gradients of the image sequence.

(i) Assuming that neighboring pixels p_1 and p_2 have the same flow vector $(u\ v)^T$, the brightness constancy constraint provides a set of linear equations for a given image patch in two consecutive frames of an image sequence (i.e. one equation per pixel). Write the system of linear equations in matrix form.

[4 marks]

(ii) Determine an expression for the flow vector $(u\ v)^T$ by using the least square solution method.

[4 marks]