1. Consider a stereo set up with the following parameters: Baseline (dx) = 100 mm; f = 10 mm; resolution of CCDs (approximately 1 cm x 1 cm size) is 101 x 101 pixels (0 …100, 0 …100); optical axes of both cameras passing through pixel (5, 5).

    Given a 3D point at (23 mm, 33 mm, 1000 mm)

    a) What is (x_l, y_l)? (2 marks)
    b) What is (x_r, y_r)? (2 marks)
    c) What is the estimated 3D point based on stereo reconstruction? (2 marks)

$$x_l = \frac{f(X-dx)}{Z} = \frac{10*(23-100)}{1000} = -0.77mm, \quad \hat{x}_l = -0.8mm$$

$$x_r = \frac{fX}{Z} = \frac{10*23}{1000} = 0.23mm, \quad \hat{x}_r = 0.2mm$$

$$y_l = y_r = \frac{fY}{Z} = \frac{10*33}{1000} = 0.33mm, \quad \hat{y}_l = \hat{y}_r = 0.3mm$$

$$\hat{Z} = \frac{fdx}{\hat{x}_r - \hat{x}_l} = \frac{10*100}{0.2+0.8} = 1000mm, \quad \hat{X} = \hat{Z}\frac{\hat{x}_l}{f} = 1000*\frac{0.2}{10} = 20mm,$$

$$\hat{Y} = \hat{Z}\frac{\hat{y}_r}{f} = 1000*\frac{0.3}{10} = 30mm.$$

a) (x_l, y_l) = (-0.77mm, 0.33mm)
b) (x_r, y_r) = (0.23mm, 0.33mm)
c) The estimated 3D point is (20mm, 30mm, 1000mm).

2. Consider two cameras with 50 mm fixed focal length lenses, set up as a stereo pair, with 100 x 100 pixel resolution on a 1 cm x 1 cm CCD surface area. What is the minimum baseline for this stereo set up to generate a depth estimation error under 1 cm at a distance of 10 meters from the cameras. Assume that the optical axes of the two cameras pass through the center of the respective CCDs. (4 marks)

$$e_x = 0.01cm, \text{ f=5cm, Z=10m=1000cm}, \quad \hat{Z} = Z(1\pm\frac{e_x Z}{fdx}) = 1000(1\pm\frac{0.01*1000}{5dx})$$

Since the error is under 1cm, $\quad 999 \leq \hat{Z} = Z(1\pm\frac{e_x Z}{fdx}) = 1000(1\pm\frac{0.01*1000}{5dx}) \leq 1001$

So $\quad dx \geq 2000cm = 20m$