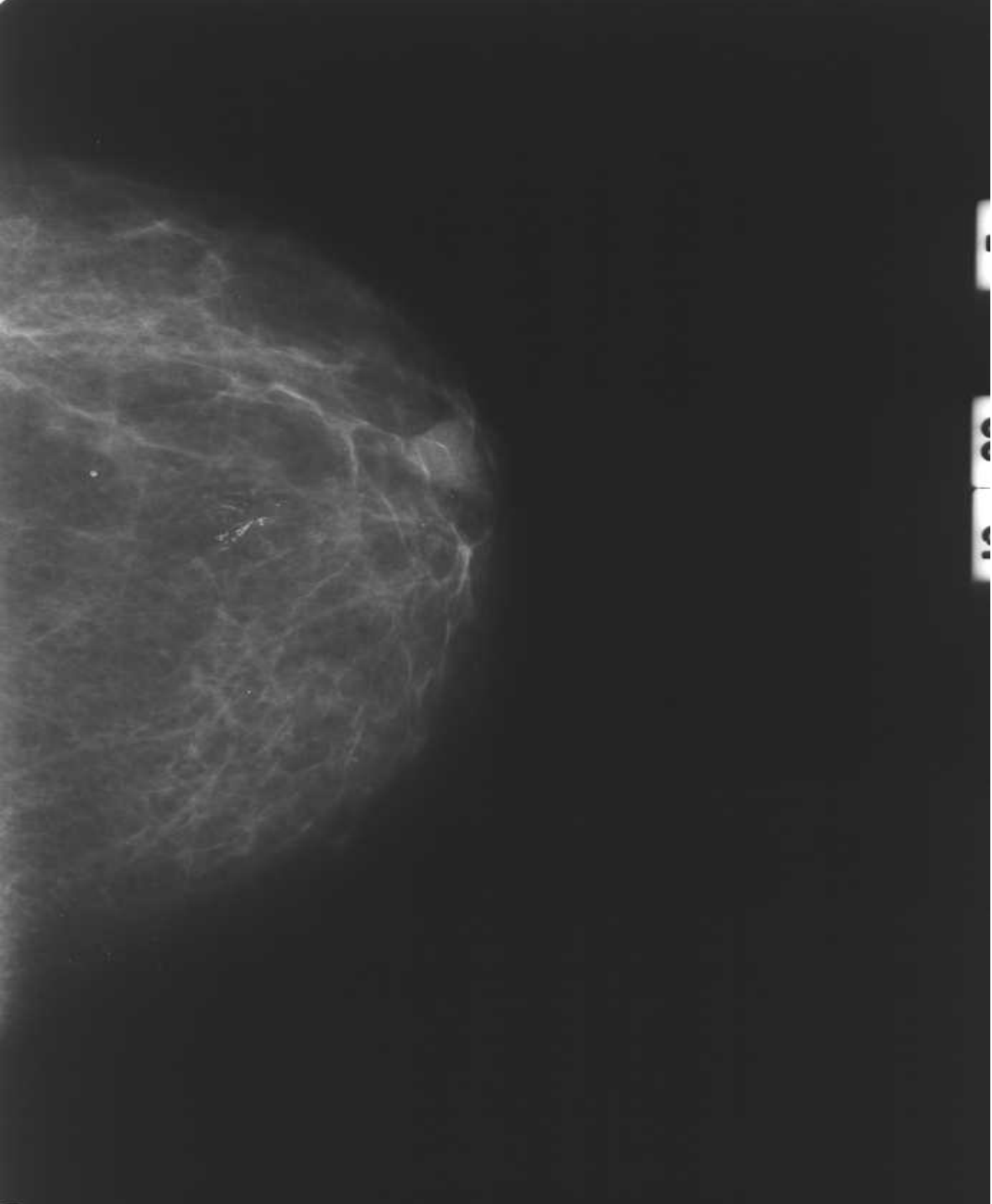


Needle placement accuracy during stereotactic localisation mammography

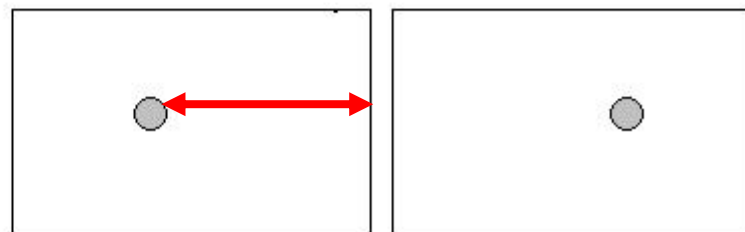
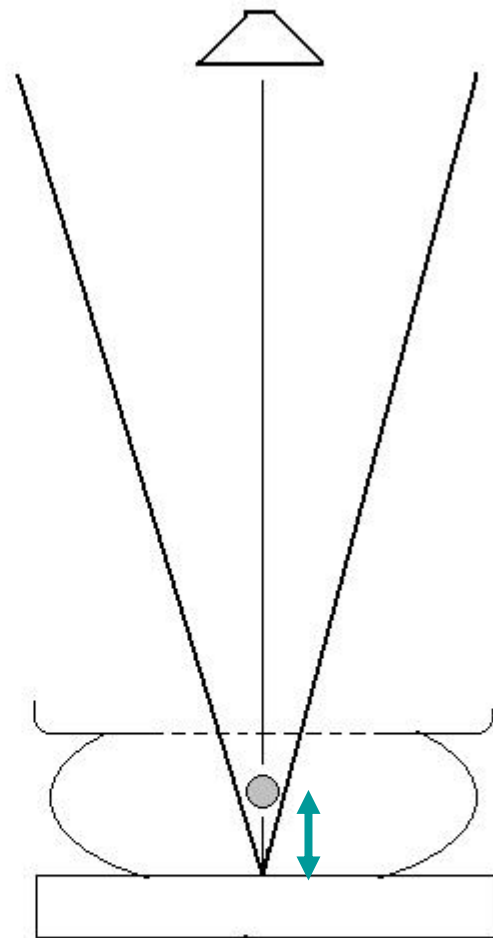
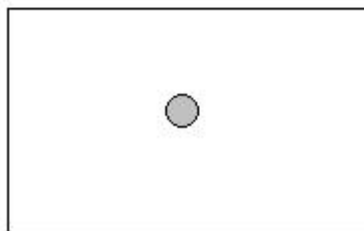
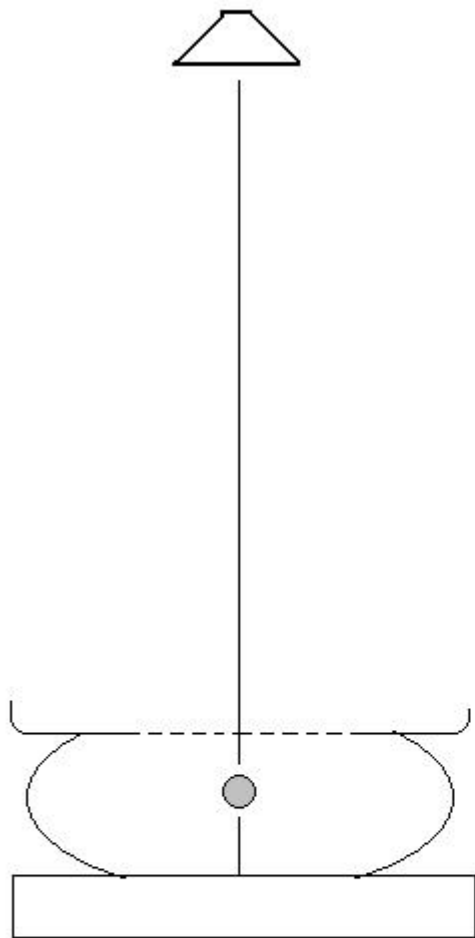
Dr David Green, BSc PhD MBChB DMRD FRCR

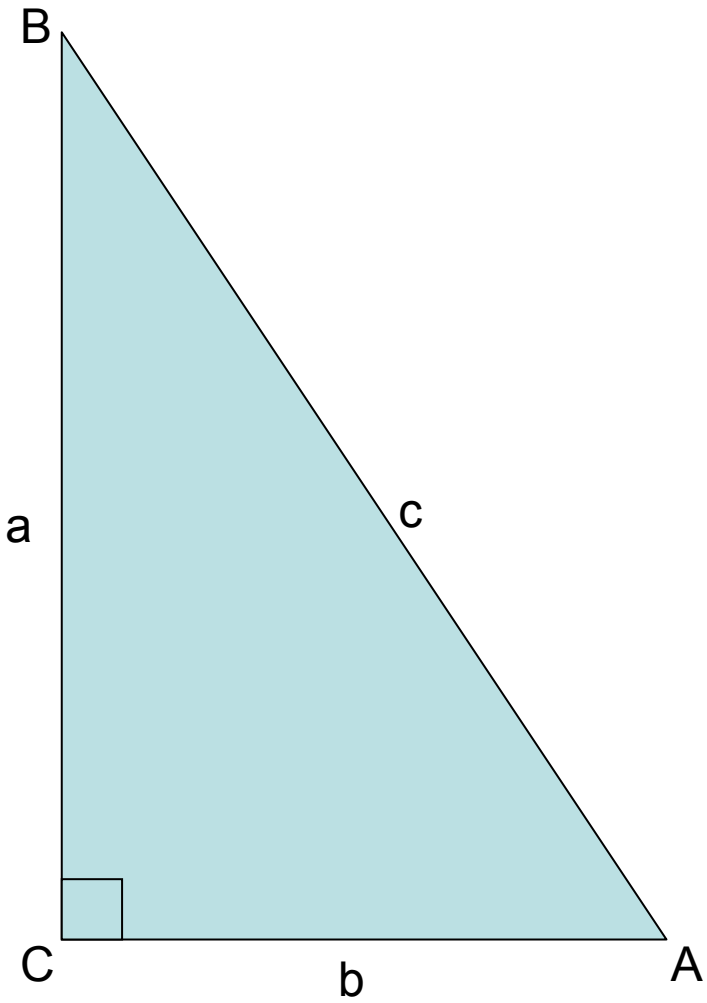
Consultant Radiologist Wirral Teaching Hospital

Programme Manager Wirral Breast Screening Unit





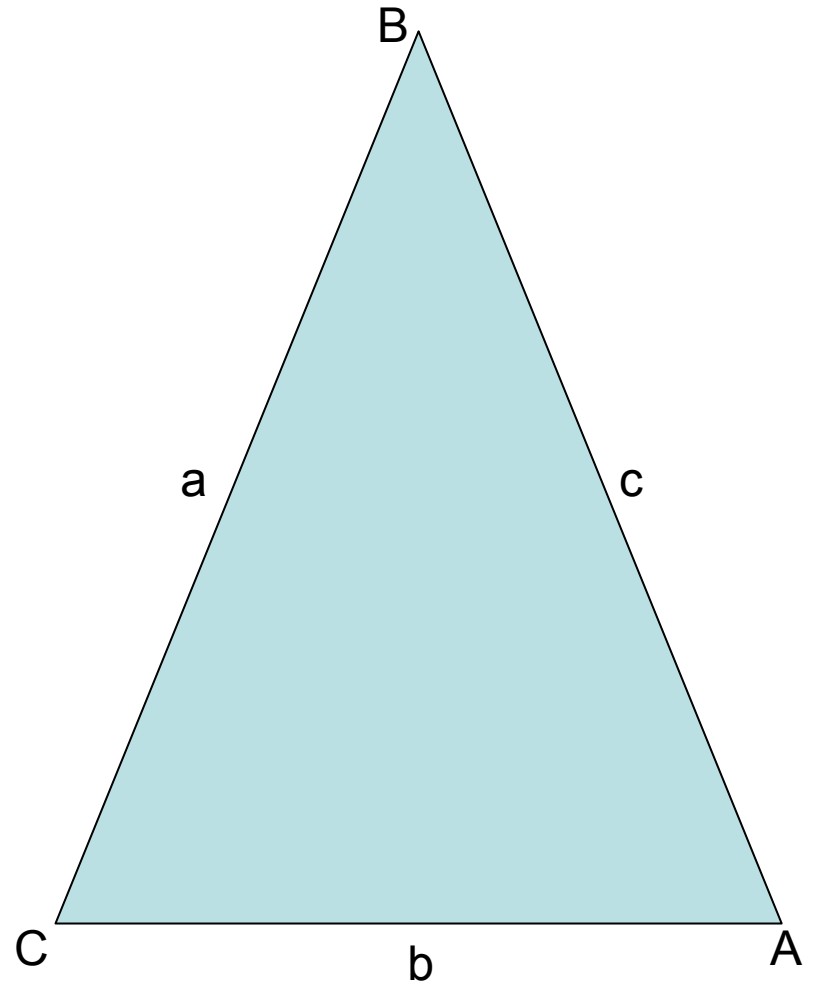




$$\sin A = a/c$$

$$\cos A = b/c$$

$$\tan A = a/b$$



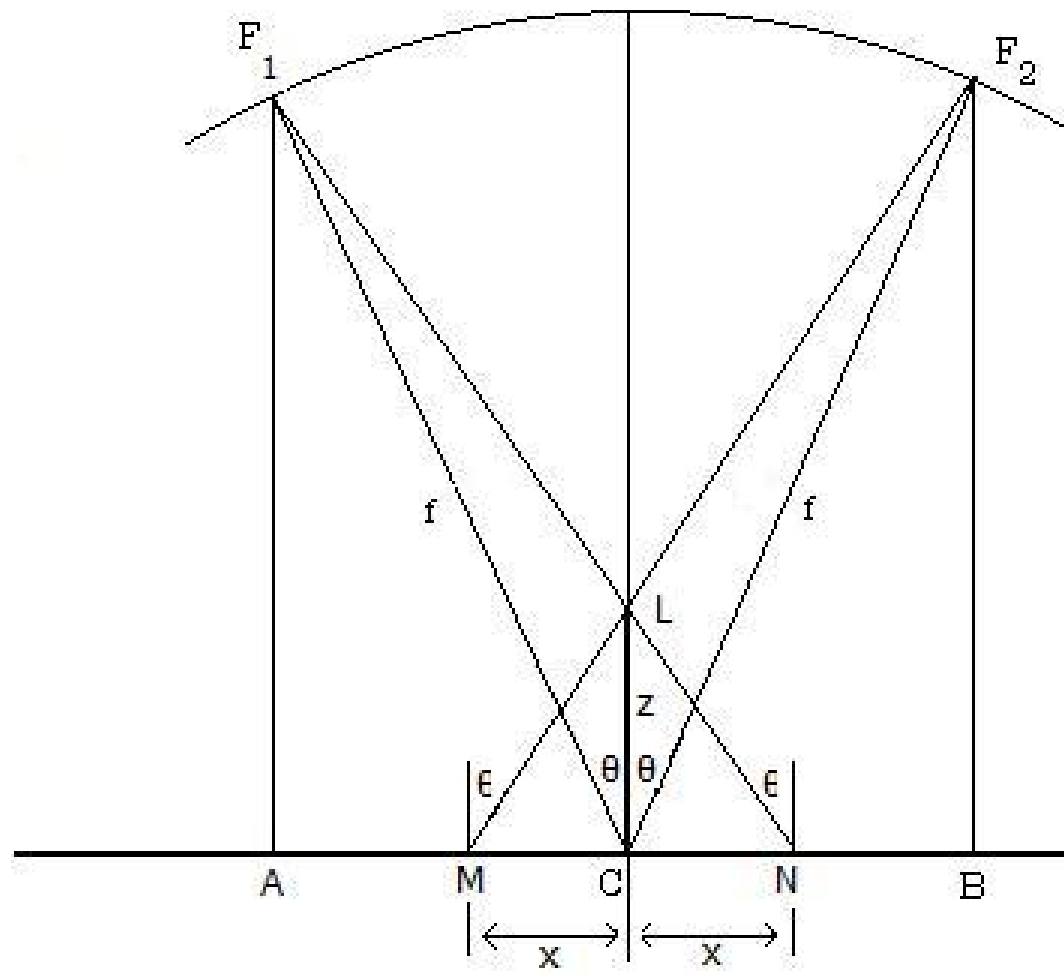
$$\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$$

$$\sin(a)/\cos(a) = \tan(a)$$

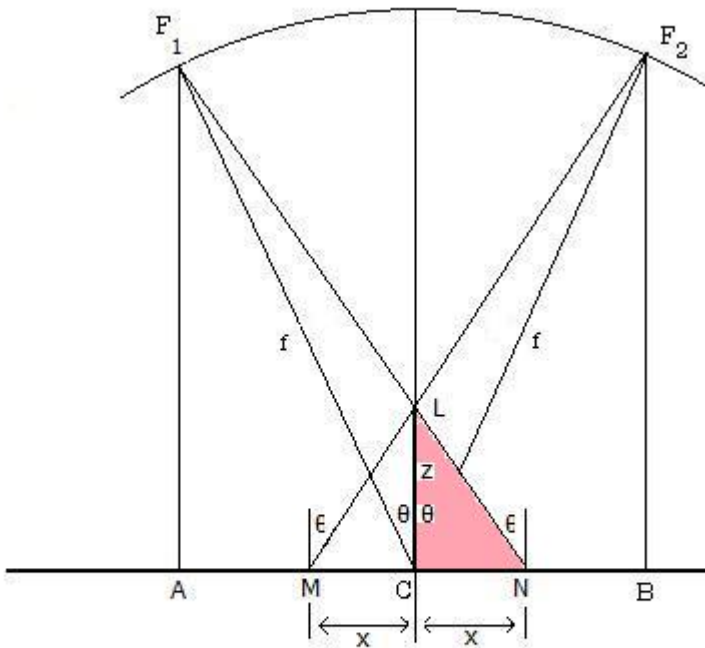
$$\sin(a+b) = \sin(a)\cos(b) + \cos(a)\sin(b)$$

$$\sin(a-b) = \sin(a)\cos(b) - \cos(a)\sin(b)$$

$$\sin(90^\circ) = 1 \quad \cos(90^\circ) = 0$$



$$\tan(\epsilon) = [MC + f\sin(\theta)]/f\cos(\theta)$$

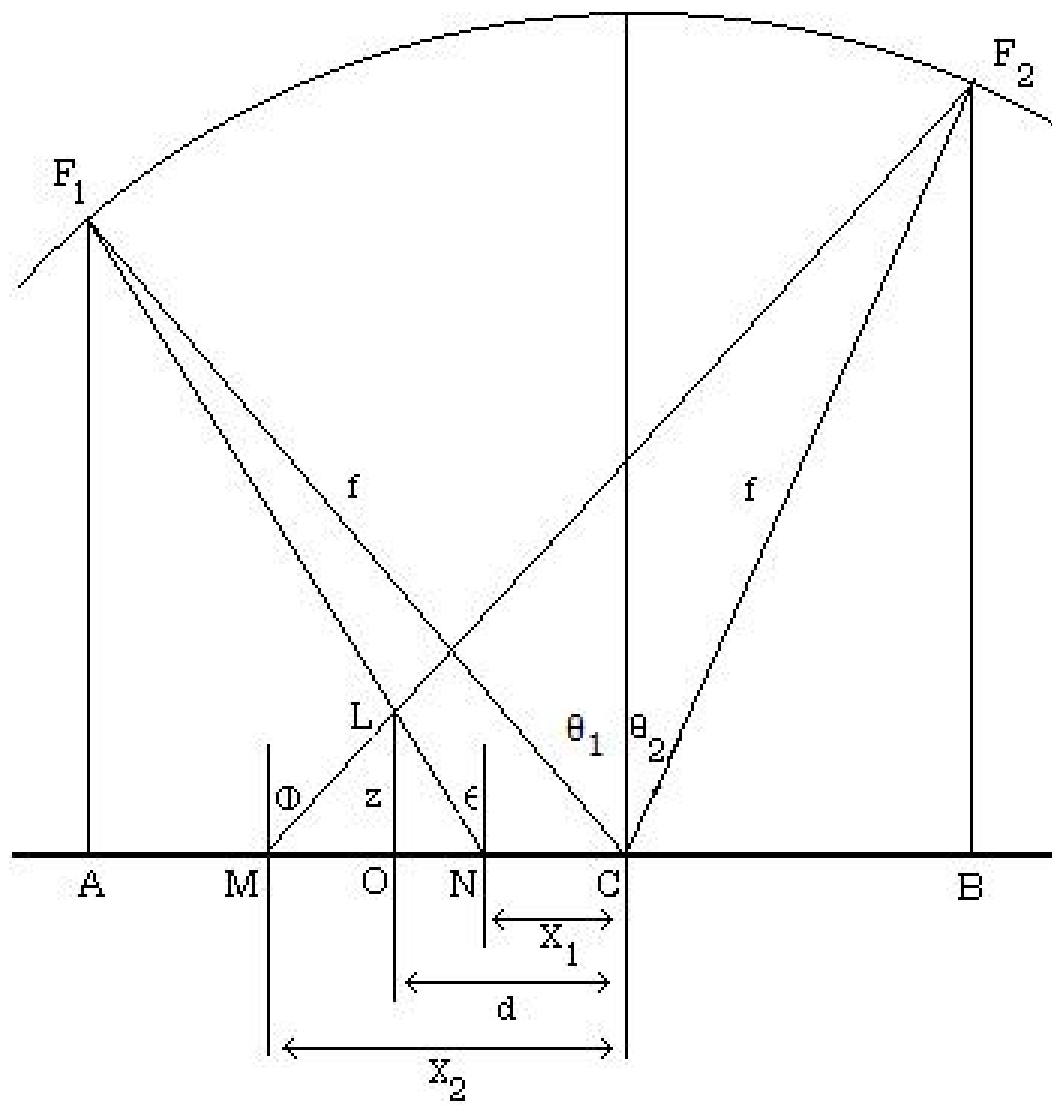


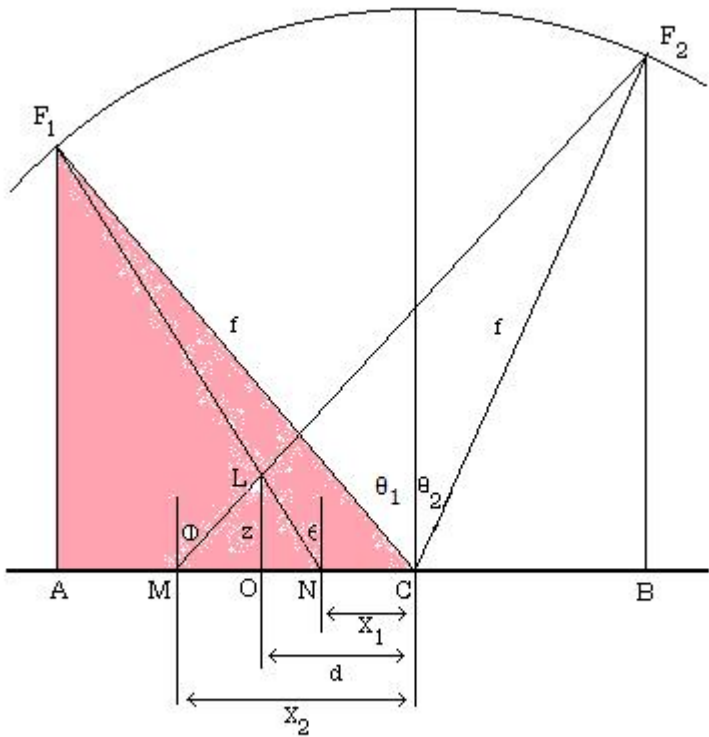
$$\tan(\epsilon) = CN/z$$

$$\therefore CN/z = [MC + f\sin(\theta)]/f\cos(\theta)$$

rearranging gives:

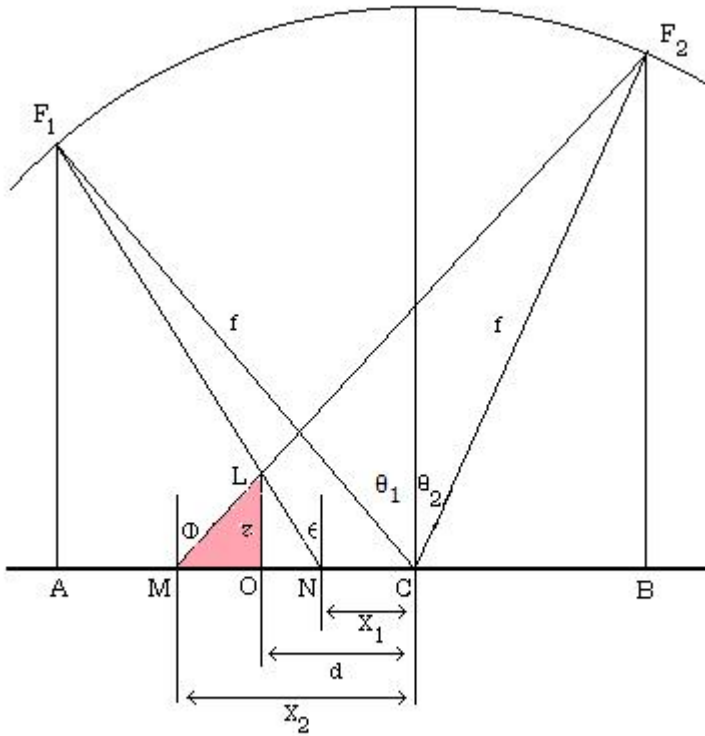
$$z = x f \cos(\theta) / [f \sin(\theta) + x]$$





$$AC = f \sin(\theta_1)$$

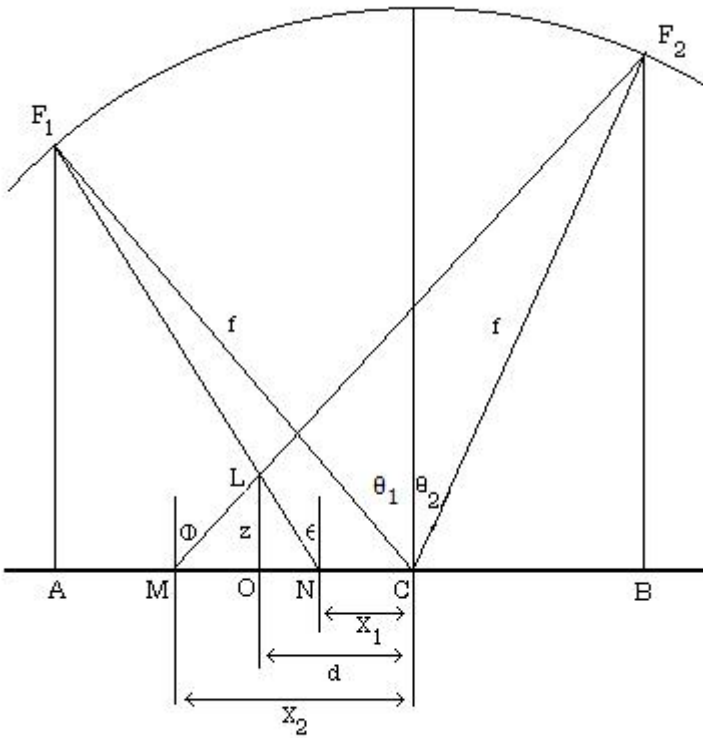
$$F_1A = f \cos(\theta_1)$$



$$\tan(\Phi) = MO/z$$

$$\therefore MO = z \tan(\Phi)$$

$$MO = z \tan(\Phi) \quad ; \quad ON = z \tan(\epsilon)$$



$$MN = MO + ON$$

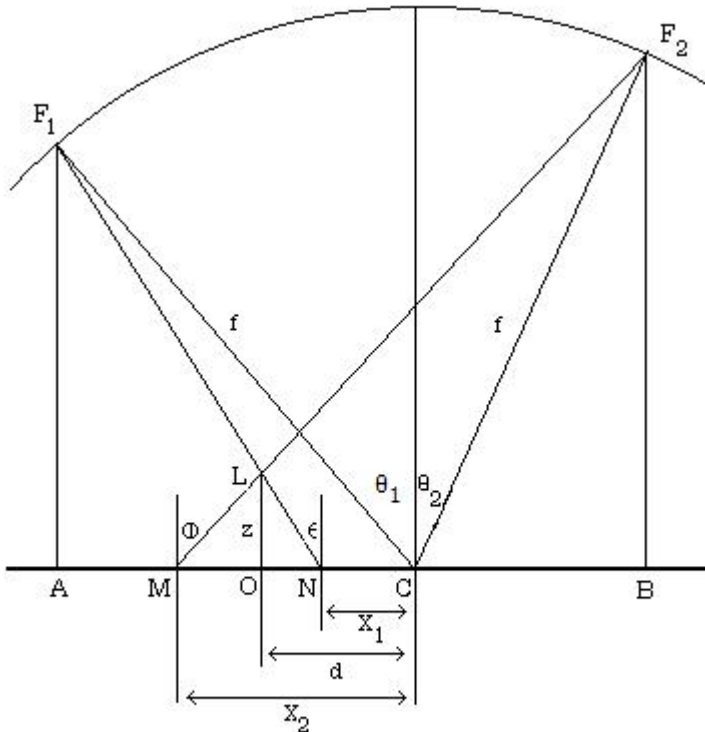
$$\therefore (x_2 - x_1) = z(\tan(\Phi) + \tan(\epsilon))$$

$$\therefore \tan(\Phi) + \tan(\epsilon) = (x_2 - x_1)/z$$

$$\tan(\Phi) = [f\sin(\theta_2) - x_2] / f\cos(\theta_2)$$

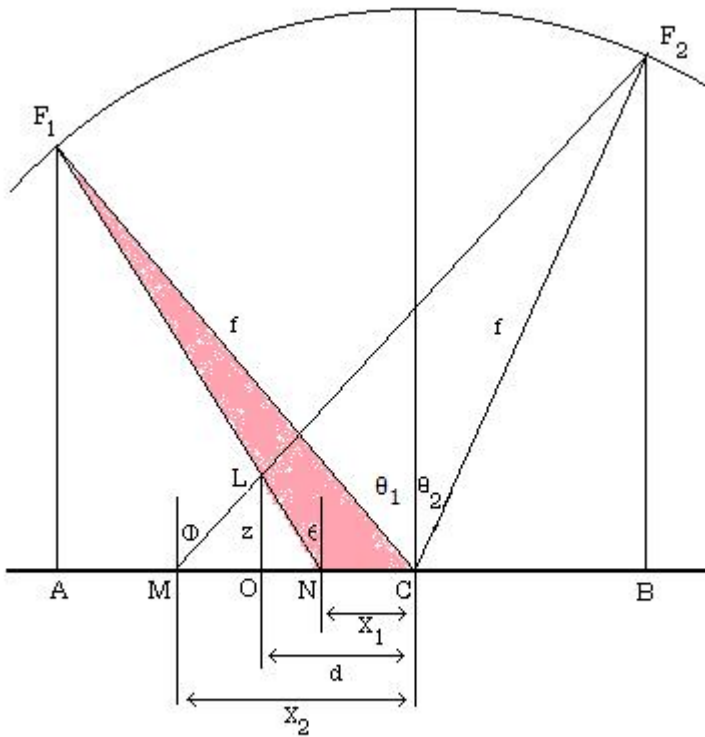
$$\tan(\epsilon) = [f\sin(\theta_1) - x_1] / f\cos(\theta_1)$$

$$\tan(\Phi) + \tan(\epsilon) = (x_2 - x_1) / z$$



Rearranging above equations leads to:-

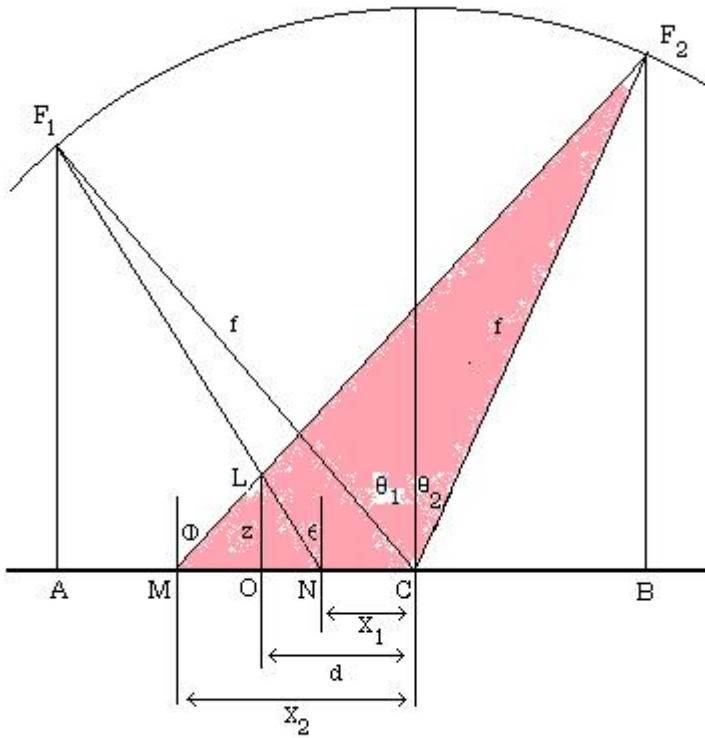
$$z = f(x_1 - x_2)\cos(\theta_1)\cos(\theta_2) / [f\sin(\theta_1 + \theta_2) + x_1\cos(\theta_2) - x_2\cos(\theta_1)]$$



$$\sin(\theta_1 - \epsilon) / x_1 = \sin(90 + \epsilon) / f$$

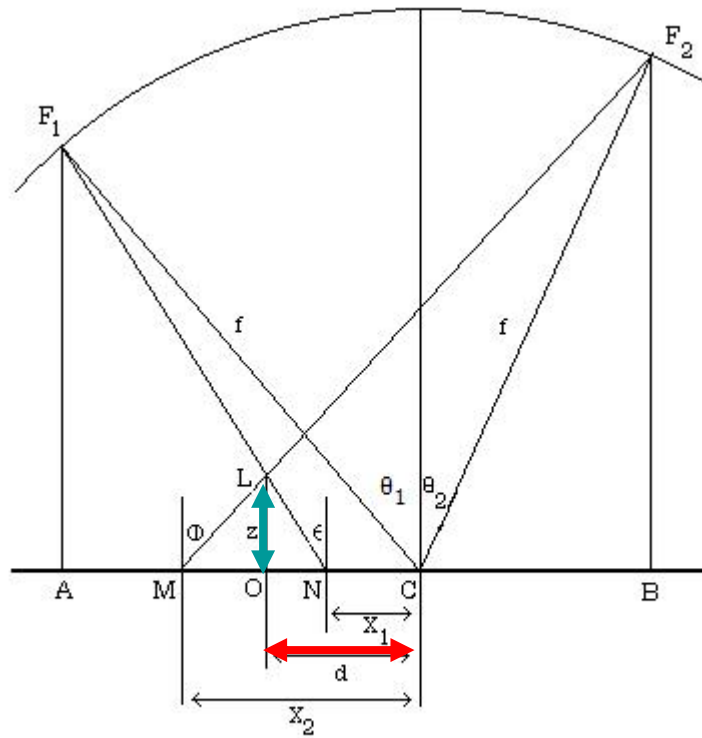
$$\therefore x_1 = f \cdot [\sin(\theta_1) - \tan(\epsilon) \cos(\theta_1)]$$

$$x_1 = f.[\sin(\theta_1) - \tan(\epsilon)\cos(\theta_1)]$$



$$\sin(\Phi - \theta_2) / x_2 = \sin(90 - \Phi) / f$$

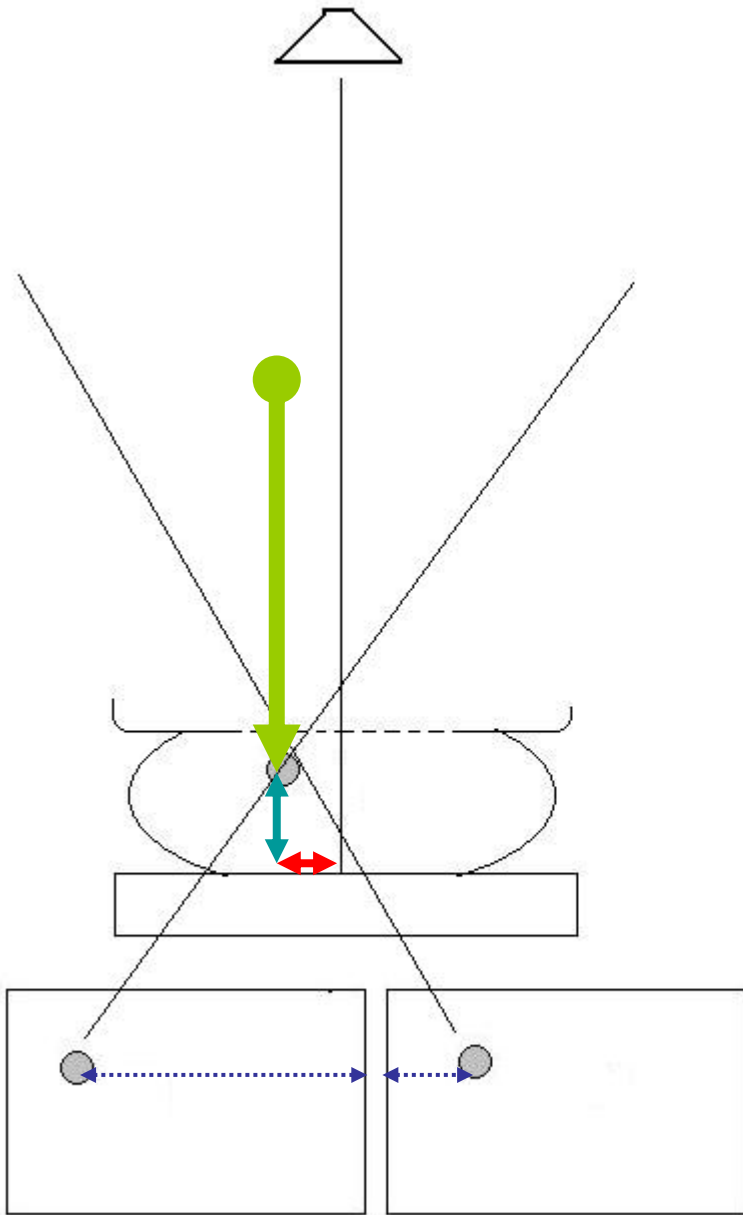
$$\therefore x_2 = f.[\tan(\Phi)\cos(\theta_2) - \sin(\theta_2)]$$



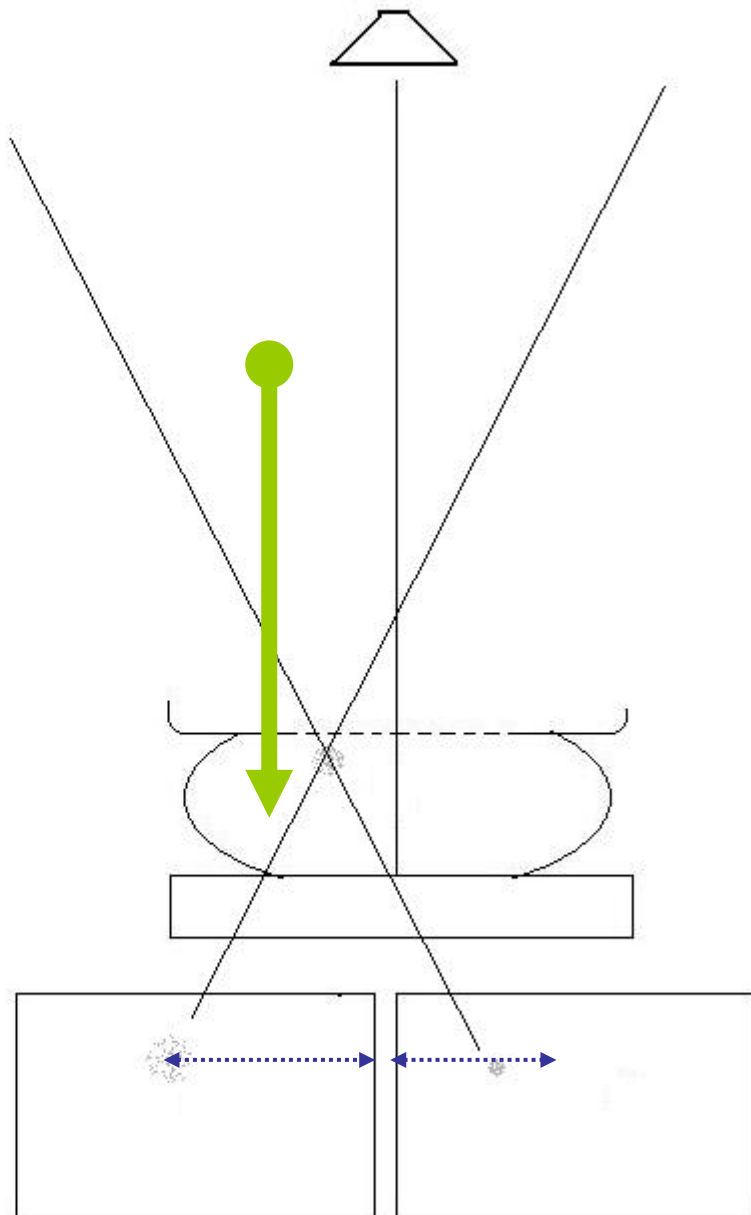
$$z = \frac{f(x_1 - x_2)\cos(\theta_1)\cos(\theta_2)}{[f\sin(\theta_1 + \theta_2) + x_1\cos(\theta_2) - x_2\cos(\theta_1)]}$$

$$d = \frac{\{x_1\cos(\theta_1)[f\sin(\theta_2) + x_2] + x_2\cos(\theta_2)[f\sin(\theta_1) - x_1]\}}{[x_2\cos(\theta_1) - x_1\cos(\theta_2) - f\sin(\theta_1 + \theta_2)]}$$

i.e. measuring x_1 and x_2 allows needle to be placed at correct height and horizontal distance from centre point, enabling accurate needle sampling



accuracy +/- 1mm



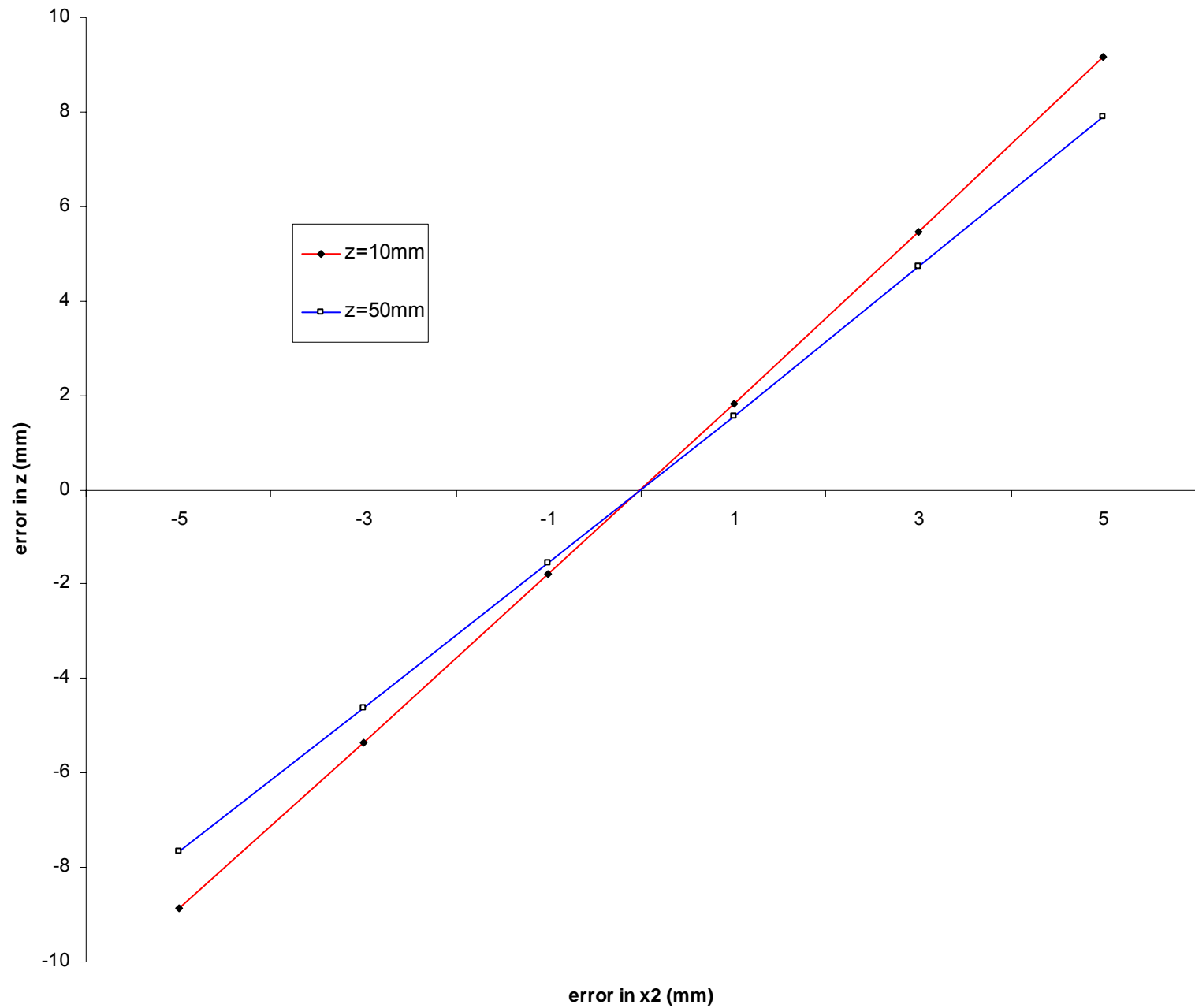
accuracy unknown

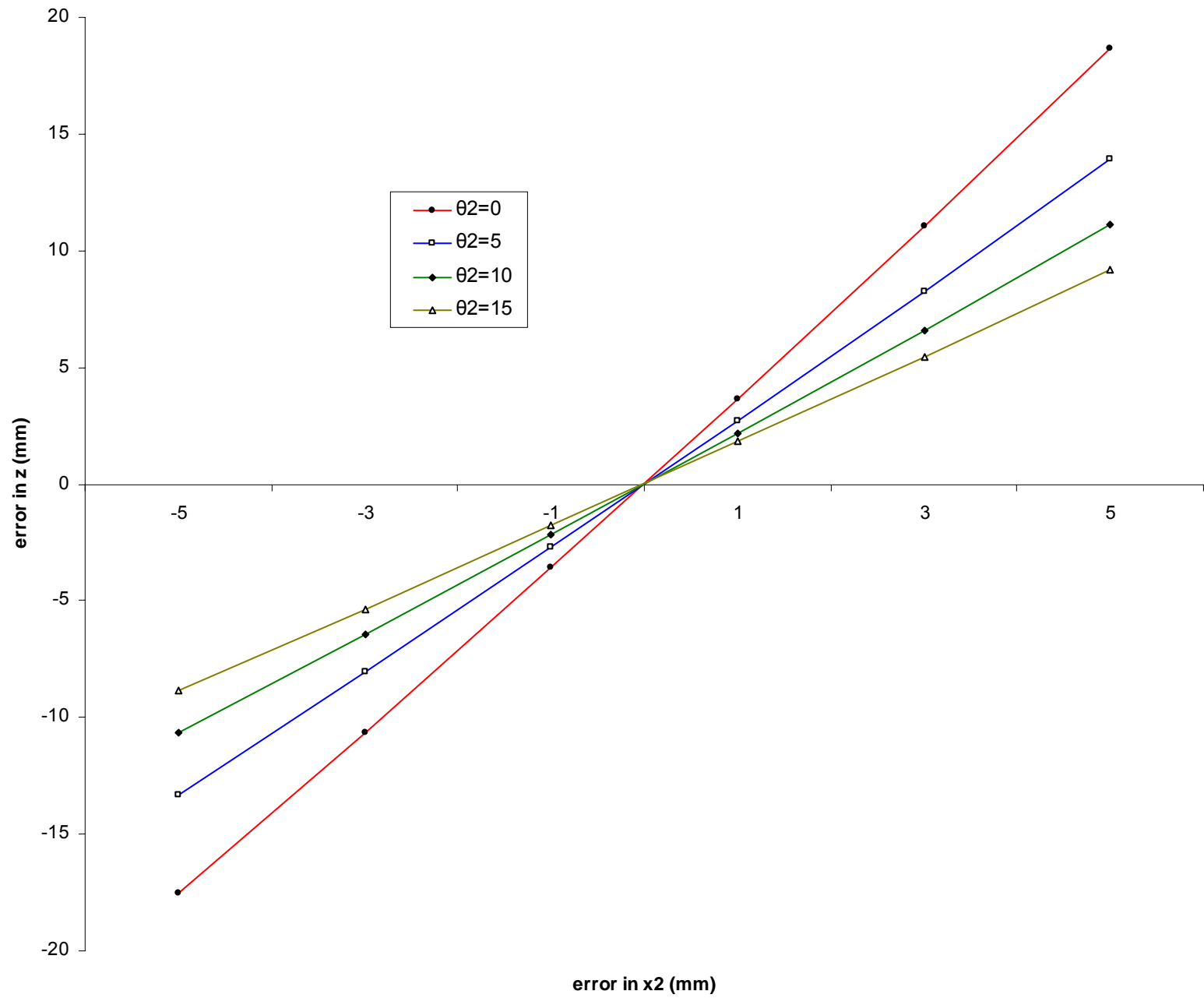
$$z = f(x_1 - x_2) \cos(\theta_1) \cos(\theta_2) / [f \sin(\theta_1 + \theta_2) + x_1 \cos(\theta_2) - x_2 \cos(\theta_1)]$$

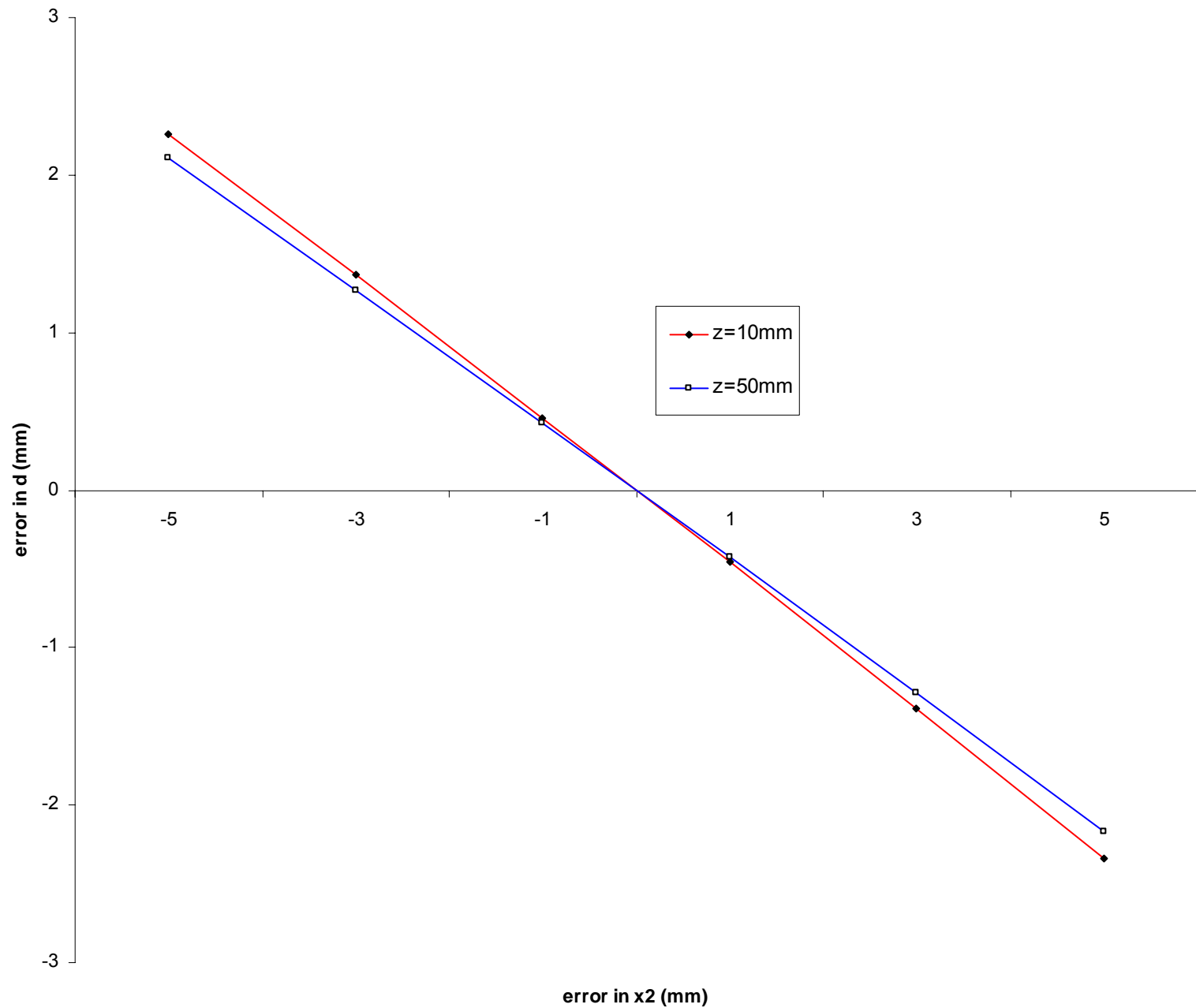
$$d = \{x_1 \cos(\theta_1) [f \sin(\theta_2) + x_2] + x_2 \cos(\theta_2) [f \sin(\theta_1) - x_1]\} / [x_2 \cos(\theta_1) - x_1 \cos(\theta_2) - f \sin(\theta_1 + \theta_2)]$$

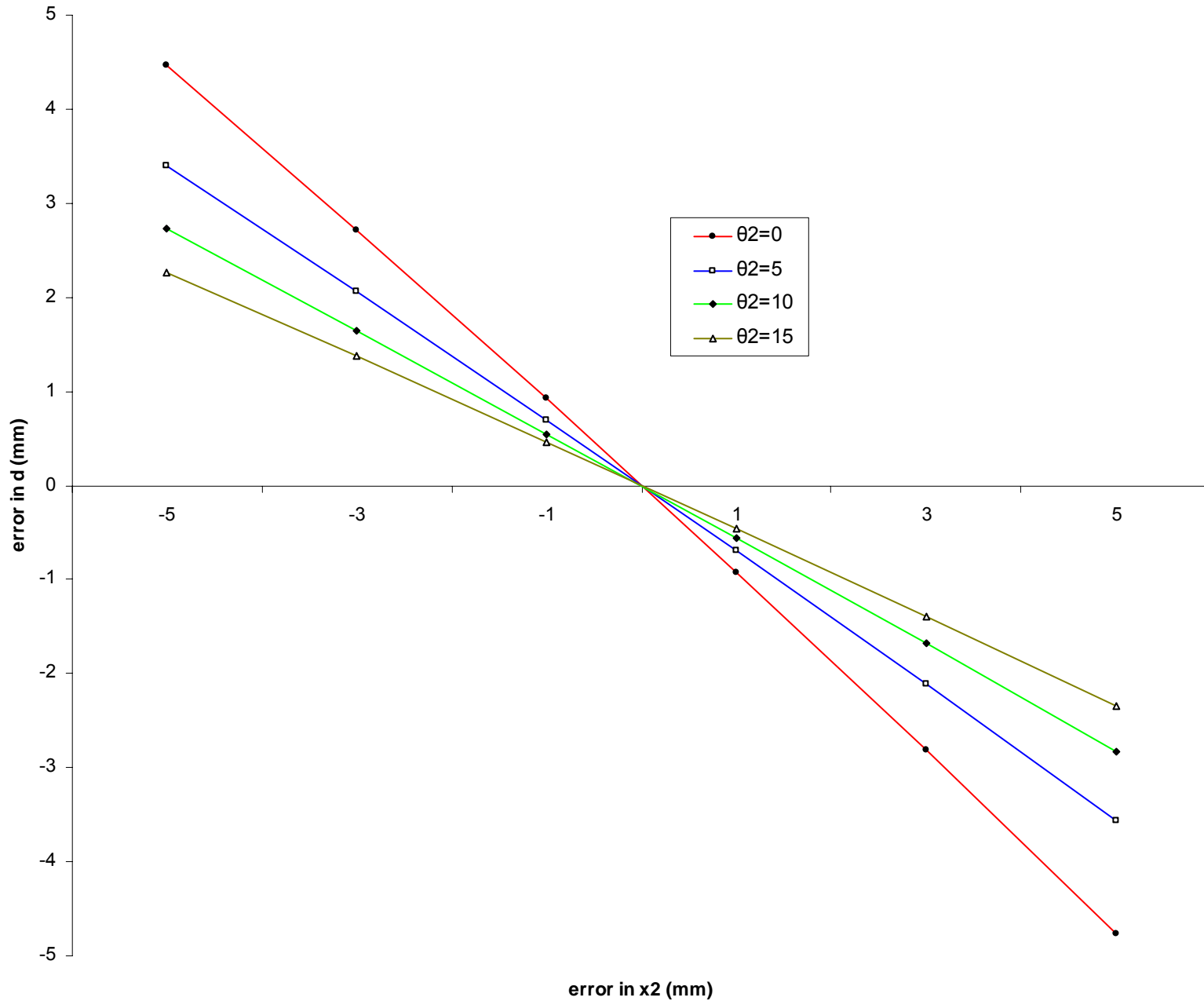
Experiment:

- (1) for known (d,z) pair calculate correct (x1,x2) values using equations above.
- (2) using (x1,x2+ ϵ) calculate resulting erroneous (d_e,z_e) values
- (3) as a result of error in x2 measurement needle placement depth error is (d-d_e) and horizontal error is (z-z_e)
- (4) repeat for various values of tube angle θ , FFD f and (d,z) pairs.





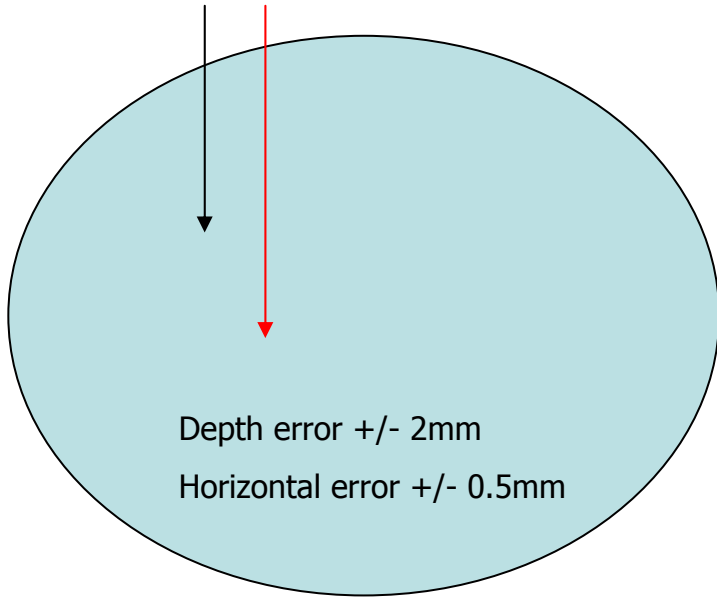




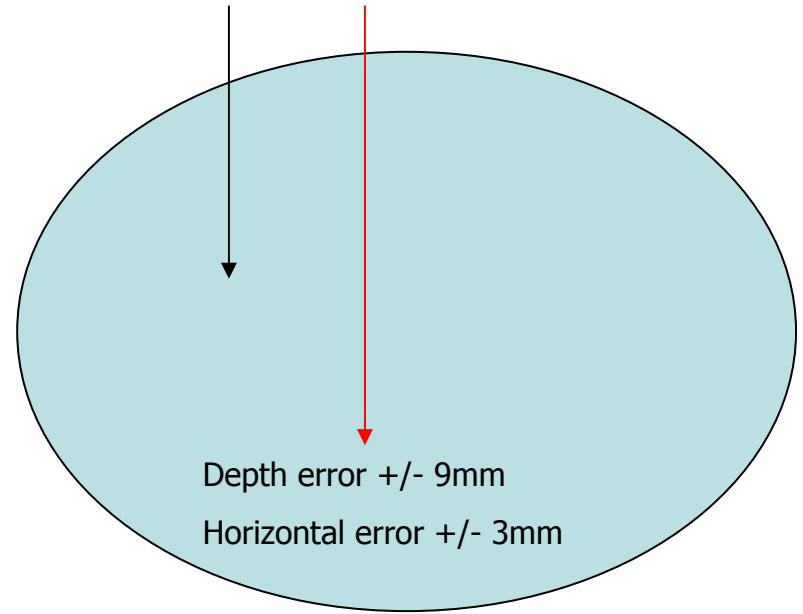
RESULTS

- (1) varying f (FFD) only produces differences in the second decimal place in errors in z and d
- (2) varying d (horizontal distance of lesion from centre point of rotation) only produces differences in the second decimal place in errors in z
- (3) there is a linear relationship between error in registration of the lesion and resulting errors in both z and d
- (4) the closer the lesion lies to the cassette in the breast the larger the resulting error in calculating z
- (5) reducing the tube swing angle results in potentially significant errors in calculating z and d

Magnitude of needle placement errors



1mm registration error



5mm registration error

Recommendations

- (1) if the lesion lies close to the film cassette, consider an alternative approach to place the lesion further away
- (2) avoid reducing the angle of tube swing
- (3) consider sampling superficial and deep to, as well as at the location indicated.
- (4) bear in mind the possibility of erroneous tissue sampling when reviewing the pathology report