1. In the mirror equation, substitute $p = 2f$:

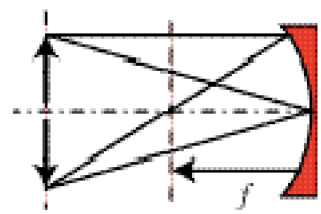
$$\frac{1}{2f} + \frac{1}{q} = \frac{1}{f}.$$

Solve for q:

$$\frac{1}{q} = \frac{1}{f} - \frac{1}{2f} = \frac{1}{2f}, \quad \text{so } q = 2f = p.$$

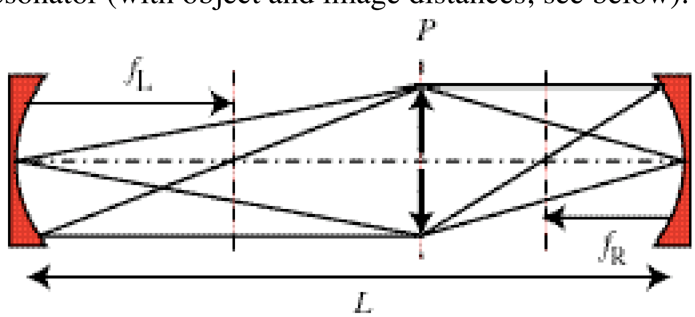
[3 marks]

Sketch:



[3 marks]

Sketch of resonator (with object and image distances; see below):



[4 marks]

Consider imaging due to the right mirror. The object distance is

$$p_1 = 40\text{mm},$$

which is $2f_R$. Therefore, like in the previous part, the image distance is the same as the object distance, i.e. $q_1 = p_1 = 40$mm, so the plane P is imaged onto itself.

[2 marks]

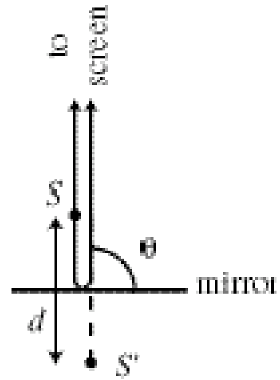
Consider imaging due to the left mirror. The image due to the right mirror acts as the object. The object distance, i.e. the distance to the left mirror, is $p_2 = 60$mm, which is $2f_L$. Therefore, $q_2 = p_2 = 60$mm, and the plane P is again imaged into itself.

[2 marks]

Reflection off the right mirror images an object in the plane P into the same plane, which is then imaged, by reflection off the left mirror, into the same plane again!

[2 marks]

2. Diagram for $\theta = 90°$:



[3 marks]

Before joining the other part, the part of the wave front that is reflected travels to the mirror and back, i.e. the path difference between the two parts is

$$\Delta = 2\, d / 2 = d.$$

Alternatively, the reflected part can be seen to be coming from *S'*, the mirror image of *S*, which is located a distance $d / 2$ on the other side of the mirror.

[2 marks]

Constructive interference occurs for

$$\Delta = d = \lambda, 2\lambda, 3\lambda, \ldots$$

[2 marks]

Either work it out the long way or use the equivalence to the double slit to find that the path difference is given by

$$\Delta = d \sin \theta \approx d\, \theta$$

(use the small-angle approximation).

[4 marks]

The second minimum occurs for path differences

$$\Delta = \pm\, 3\lambda / 2,$$

[3 marks]

so

$$d\, \theta \approx \pm\, 3\lambda / 2.$$

Solve for θ:

$$\theta \approx \pm\, 3\lambda / (2\, d) = \pm\, 1.2\ 10^{-2}\ \text{(rad)} \approx \pm\, 0.68°.$$

[2 marks]