Solution of problem 1:

a) The total resistance of the apparatus is $Z = \frac{228.5\,\text{V}}{0.6\,\text{A}} = 380.8\,\Omega$,

the ohmic resistance of the tube is $R_R = \frac{84\,\text{V}}{0.6\,\text{A}} = 140\ \Omega$.

Hence the total ohmic resistance is $R = 140\,\Omega + 26.3\,\Omega = 166.3\,\Omega$.

Therefore the inductance of the series reactor is: $\omega \cdot L = \sqrt{Z^2 - R^2} = 342.6\,\Omega$.

This yields $L = \frac{342.6\,\Omega}{100\,\pi\,\text{s}^{-1}} = 1.09\ \text{H}$.

b) The impedance angle is obtained from $\tan\varphi = \frac{\omega \cdot L}{R} = \frac{342.6\,\Omega}{166.3\,\Omega} = 2.06$.

Thus $\varphi = 64.1^\circ$.

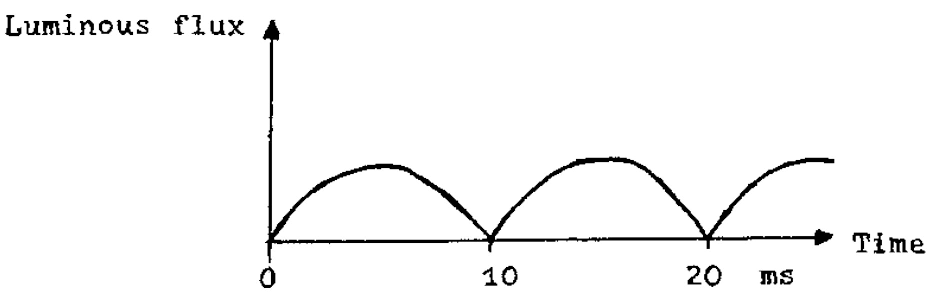
c) The active power can be calculated in different ways:

1) $P_w = U \cdot I \cdot \cos\varphi = 228.5\,\text{V} \cdot 0.6\ \text{A} \cdot \cos 64.1^\circ = 59.88\ \text{W}$

2) $P_w = R \cdot I^2 = 166.3\,\Omega \cdot (0.6\ \text{A})^2 = 59.87\ \text{W}$

d) By opening the contact in the starter a high induction voltage is produced across the series reactor (provided the contact does not open exactly the same moment, when the current goes through zero). This voltage is sufficient to ignite the lamp. The main voltage itself, however, is smaller than the ignition voltage of the fluorescent tube.

e)



f) The recombination time of the ions and electrons in the gaseous discharge is sufficiently large.

g) The capacitive resistance of a capacitor of 4.7 μF is

$$\frac{1}{\omega \cdot C} = (100 \cdot \pi \cdot 4.7 \cdot 10^{-6})^{-1}\ \Omega = 677.3\ \Omega .$$

The two reactances subtract and there remains a reactance of 334.7 Ω acting as a capacitor.

The total resistance of the arrangement is now

$$Z' = \sqrt{(334.7)^2 + (166.3)^2}\ \Omega = 373.7\ \Omega ,$$

which is very close to the total resistance without capacitor, if you assume the capacitor to be loss-free (cf. a)). Thus the lamp has the same operating qualities, ignites the same way, and a difference is found only in the impedance angle φ', which is opposite to the angle φ calculated in b):

$$\tan \varphi' = \frac{\omega \cdot L - (\omega \cdot C)^{-1}}{R} = -\frac{334.7}{166.3} = -2.01$$

$$\varphi' = -63.6^\circ .$$

Such additional capacitors are used for compensation of reactive currents in buildings with a high number of fluorescent lamps, frequently they are prescribed by the electricity supply companies. That is, a high portion of reactive current is unwelcome, because the power generators have to be layed out much bigger than would be really necessary and transport losses also have to be added which are not payed for by the customer, if pure active current meters are used.

h) The uncoated part of the demonstrator lamp reveals the line spectrum of mercury, the coated part shows the same line spectrum over a continuous background. The continuous spectrum results from the ultraviolet part of the mercury light, which is absorbed by the fluorescence and re-emitted with smaller frequency (energy loss of the photons) or larger wavelength respectively.

Problem 2: Oscillating coat hanger

A (suitably made) wire coat hanger can perform small amplitude oscillations in the plane of the figure around the equilibrium positions shown. In positions a) and b) the long side is