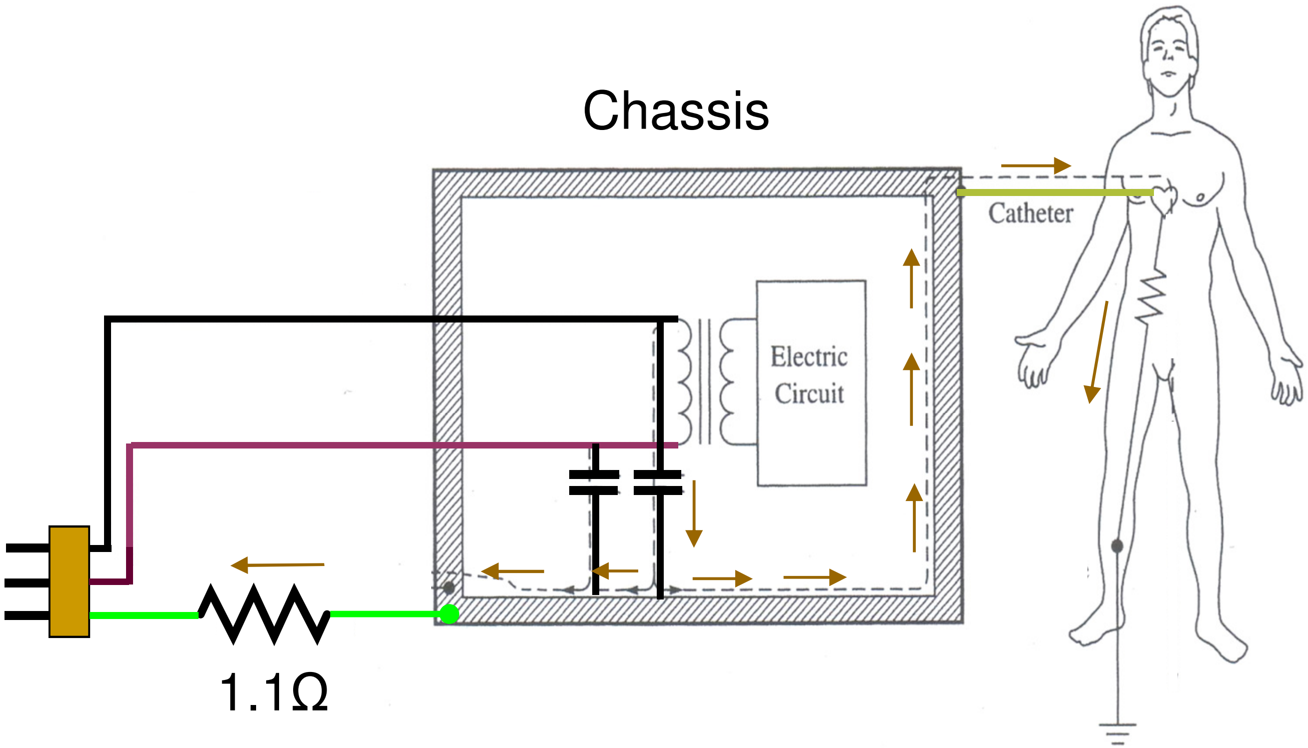
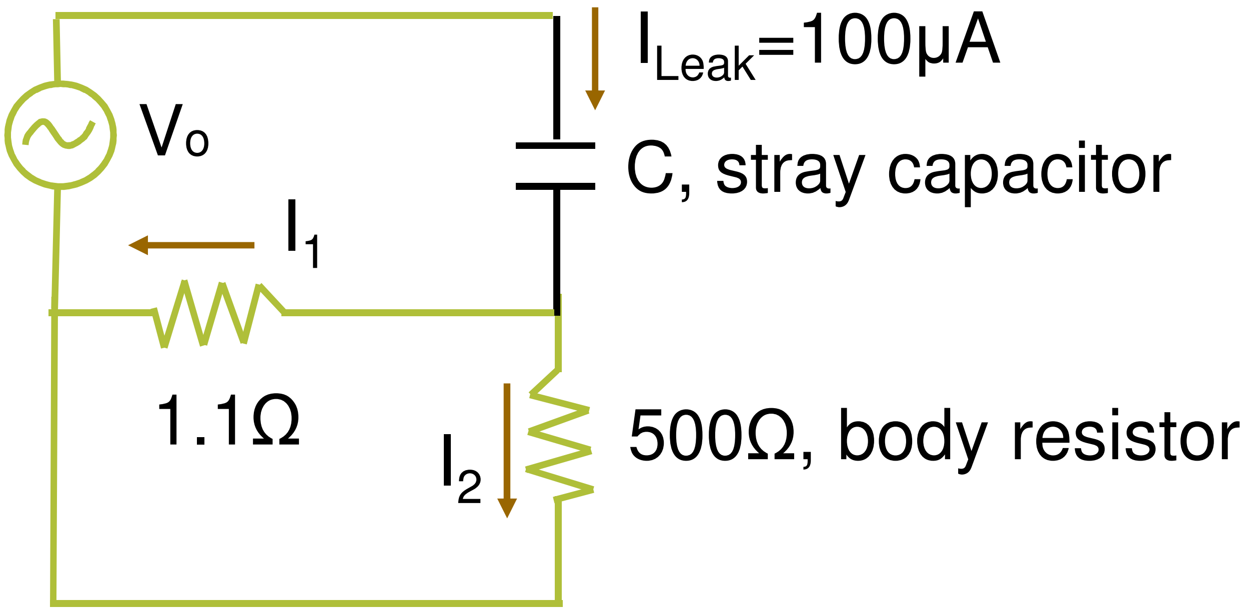
Tutorial 4

Question 1: Suppose that the leakage current is 100 μA. If the ground wire resistance is 1.1Ω and a patient of 500-Ω resistance touches the instrument metal case, what is the body current?



Solution:

The equivalent circuit of **question 1** is

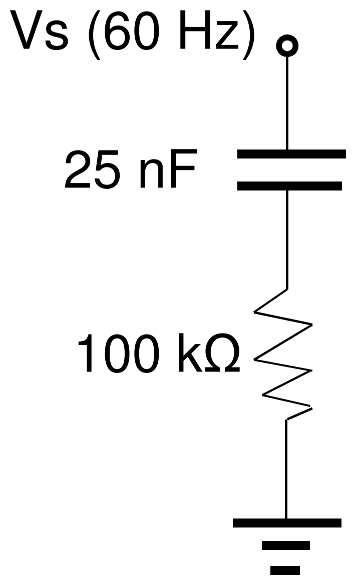


$$I_2 = \frac{1.1\Omega}{500\Omega + 1.1\Omega} \times 100\mu A = 0.2\mu A$$

$I_2 = 0.2\ \mu A,\ I_1 = 99.8\ \mu A,$

Question 2 A power engineer receives a lethal macroshock while standing in water and simultaneously touching the ungrounded metal casing on a high-voltage, 60-Hz power transformer. Assume that the resistance of the skin on the engineering's hand is 100 kΩ and the resistance of the skin on the engineer's feet is negligible. A capacitance of 25 nF is measurement between the transformer casing and the high-voltage conductors. Find the minimal value of the high voltage, assuming that 75 mA is the minimal fibrillating macroshock. Draw an equivalent circuit.

Solution:

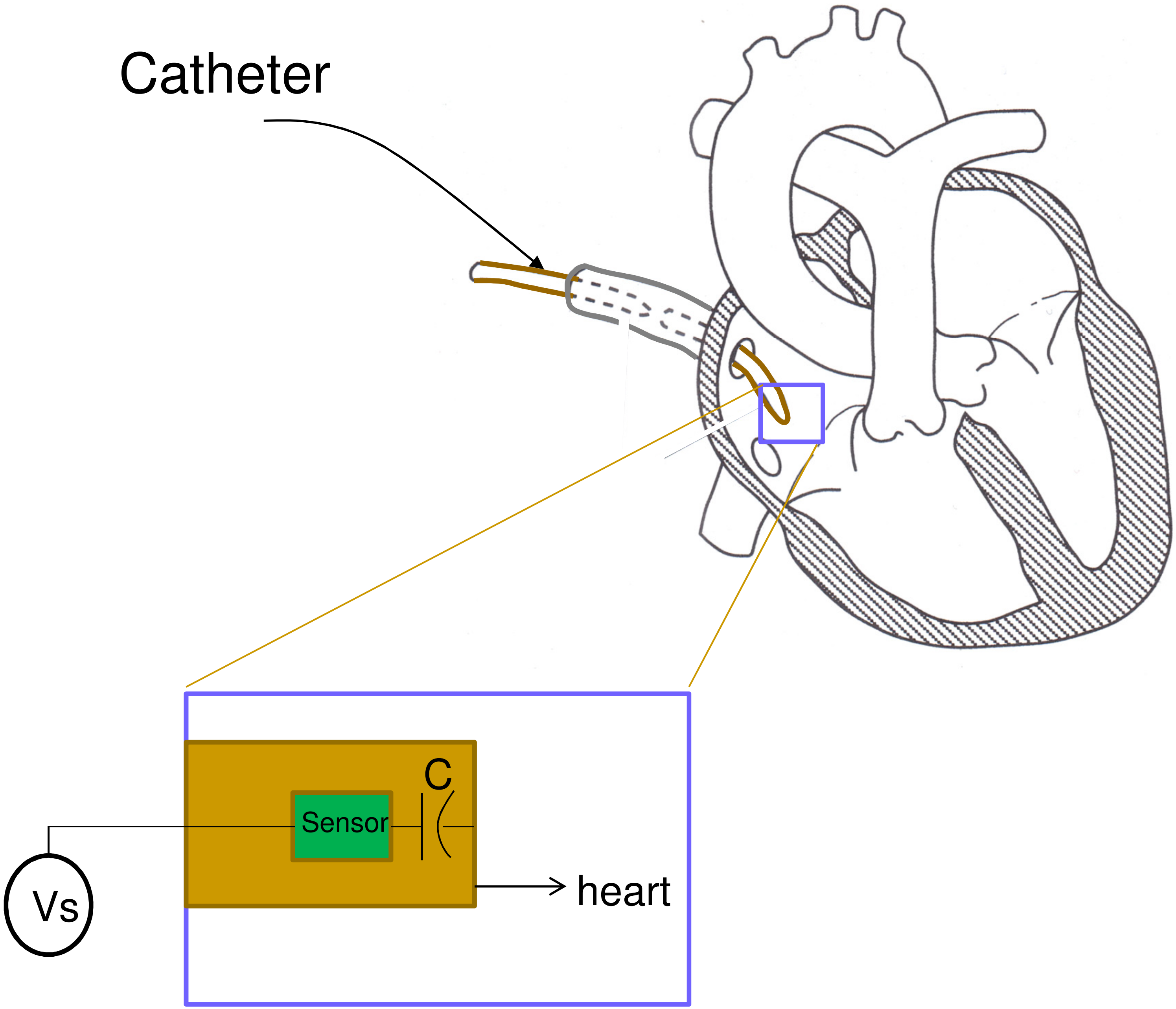


$$\frac{V_s}{75mA} \geq \left|R + \frac{1}{j\omega C}\right|, \text{ and } \omega = 2\pi \times 60\ Hz$$

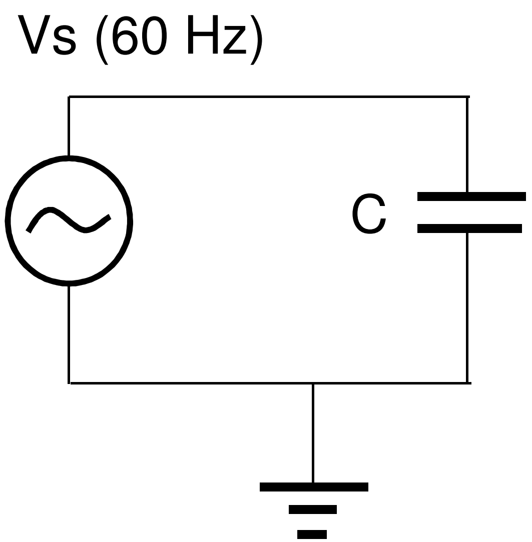
$$\frac{V_s}{75mA} \geq \left(R^2 + \left(\frac{1}{\omega C}\right)^2\right)^{\frac{1}{2}} \geq (10^{10} + 1.1236\times10^{10})^{\frac{1}{2}} \geq 1.4573\times10^5$$

There for $V_s \geq 10929V$

Question 3 Calculate the maximal safe capacitance between a liquid-filled catheter and dc-isolated pressure-sensor leads for a 120-V, 60-HZ fault in the sensor leads. Assuming that 10 uA is the minimal fibrillating microshock.


Catheter
C
Sensor
Vs
heart

Solution:



I_{VF} = 10 uA,

$$\frac{V_s}{I_{VF}} < \left| R + \frac{1}{j\omega C} \right|$$, since body resistance is negligible

So $\frac{V_s}{I_{VF}}$ = 120V/10uA< $\left|\frac{1}{j\omega C}\right|$,

In which $\omega = 2\pi \times 60Hz$,

Therefore C < 220 pF