

Please select two and only two questions out of the three questions. Write clearly your answers to the questions you choose. Each correctly answered question is 2 bonus points counted towards the final grade. Very limited partial grades will be given. So write very neatly and state clearly your reasoning. If three problems were chosen, the two answers with LOWER points would be counted.

1. You are given a volt meter with internal resistance greater than $99 \text{ k}\Omega$ ($1 \text{ k}\Omega = 1000 \Omega$) and an ampere meter with internal resistance smaller than 0.01Ω . The voltage and current you read from these two meters carry enough significant digits for the problem you need to answer. You are also given a battery with emf 9.00 V and internal resistance 5Ω . With these three tools, (a) if you connect a circuit in the diagram shown in figure 1, what is the smallest resistance you can measure with a precision better than 1%? (b) if you connect a circuit in the diagram shown in figure 2, what is the largest resistance you can measure with a precision better than 1%? (c) if you have a resistor with a resistance outside of the range you get from (a) and (b), discuss what connection you have to choose in order to achieve a measurement precision better than 1%?

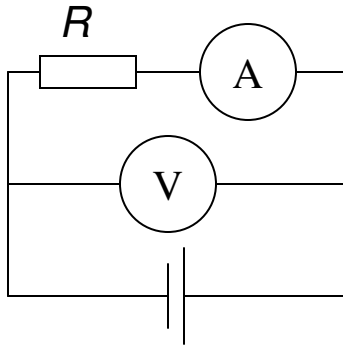


Figure 1

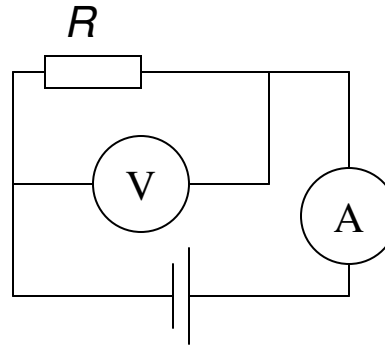


Figure 2

2. You are given a converging thin lens ($f_1 = 150$ mm) and a diverging thin lens ($f_2 = -10$ mm) . Please construct a telescope in such a way that an object 50 meters in front of your eyes has an angular magnification of at least 50, with a non-inverted image. State clearly how you place the two thin lenses and prove in such a configuration the image fulfill the requirements.

3. Shown in the following figure is a device to count photon numbers. Photons hit the front face of the photo multiplier tube (PMT) generate electrons. Assume one photon generates one electron (in reality one photon has 20-40% chances to generate one electron). These electrons are linearly amplified by the PMT by a factor of 10^7 . These amplified electrons pass through a 50Ω resistor to go to ground. An oscilloscope is connected to the resistor and reads the signal. When there is no photon incidence, the PMT front face can also release electrons that cause a signal on the oscilloscope. These signals are called the dark current. If you measure a dark current signal shown in the figure, can you use the PMT to count at least two photons at a time? If not, what would be the maximum pulse height of the dark current (assuming the bottom width of the pulse stays the same) in order for you to count at least two photons at a time. If you are asked to perform this measurement, where you should set your trigger threshold?

