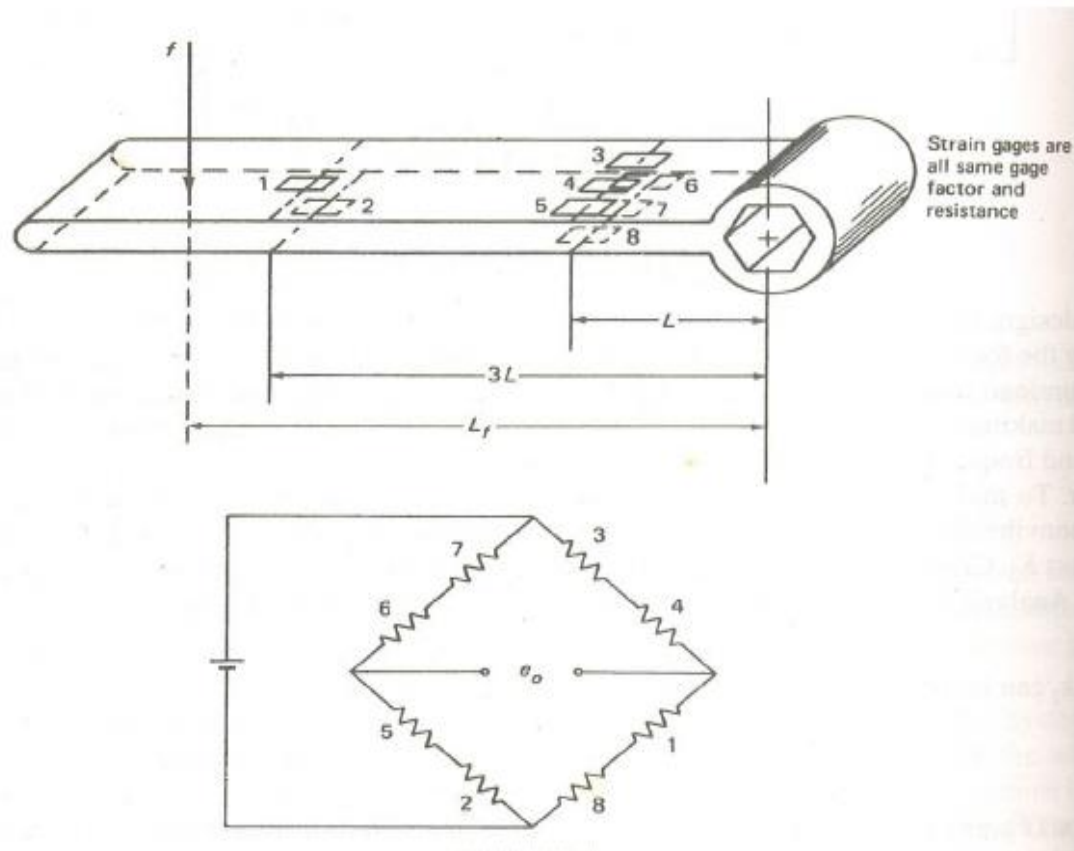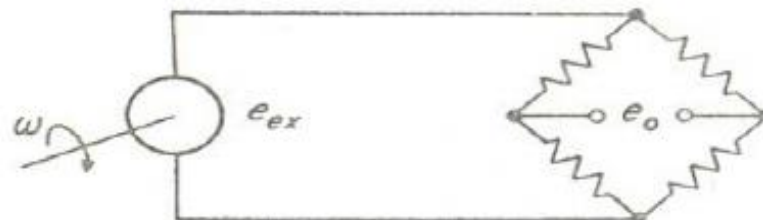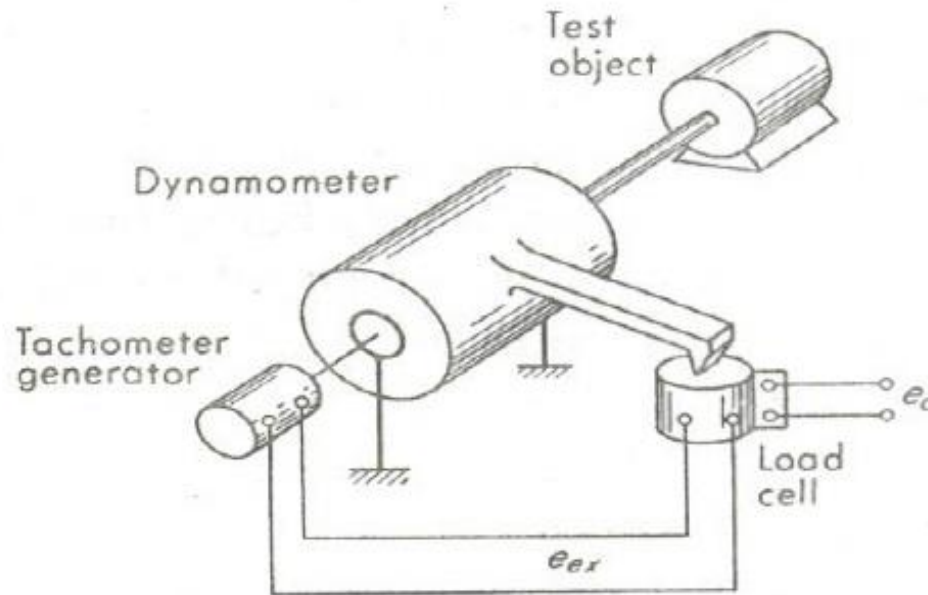## Problem (Time to solve - 10 min)

The torque wrench in the figure given below is claimed to produce an output voltage e_o proportional to the torque applied by force f to the nut, irrespective of the point of force application L_f, as long as $L_f > 3L$. Investigate the validity of this claim. Assume all the gauges have same gauge factor and same resistance(under no strain).


Strain gages are all same gage factor and resistance

Problem (Time to solve - 10 min)

Suppose the tachometer generator in the system of the following figure puts out 6V/1000rev/min and the load cell produces 0.011mV/N.V. What will be the power calibration factor for e_o in horsepower per milli volt if the arm length is 300mm?

Find the gain of the circuits. Assume ideal op-amp.
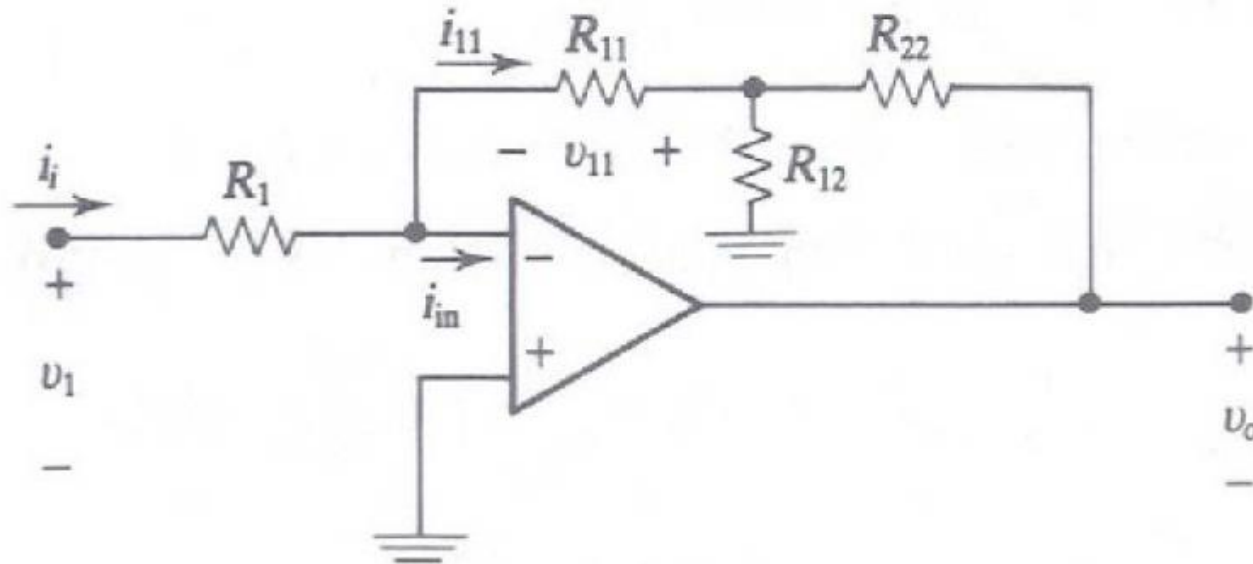
Q1) Design an OpAmp circuit. Input voltage range 0.3V-1.0V output voltage 0.5 V to 4.5 V.

An object with a volume of $160cc$ is weighed on an equal arm balance. The standard mass required for balance is $0.5\ kg$ and has a volume of $50cc$. What is the value of correction necessary for air buoyancy?

Problem (Time to solve - 10 min)

A mercury thermometer has a capillary tube of 0.25 mm diameter. If the bulb is made of a zero expansion material, what volume must it have if a sensitivity of 4 mm/$^\circ C$ is desired? Assume operation near 20 $^\circ C$.

For mercury, Linear expansion coeff. $= 60 \times 10^6 m/m -^\circ C$.

Problem (Time to solve - 10 min)

A balloon carrying a first order thermometer, with a 15s time constant, rises through the atmosphere at 6m/s. Assume temperature varies with altitude at 0.15 °C/30m. The balloon radios temperature and altitude readings back to ground. At 3000m the balloon says the temperature is 0°C. What is the true altitude at 0°C occurs?

Problem (Time to solve - 10 min)

A measuring instrument with a time constant of 0.4s and a static sensitivity of 0.01mV/°C is used to measure the temperature of a medium, which changes from 15 to 80°C. Taking the output as zero at 15°C, find the time taken for the output voltage to reach 70% of the steady state value, if the temperature change occurs suddenly.