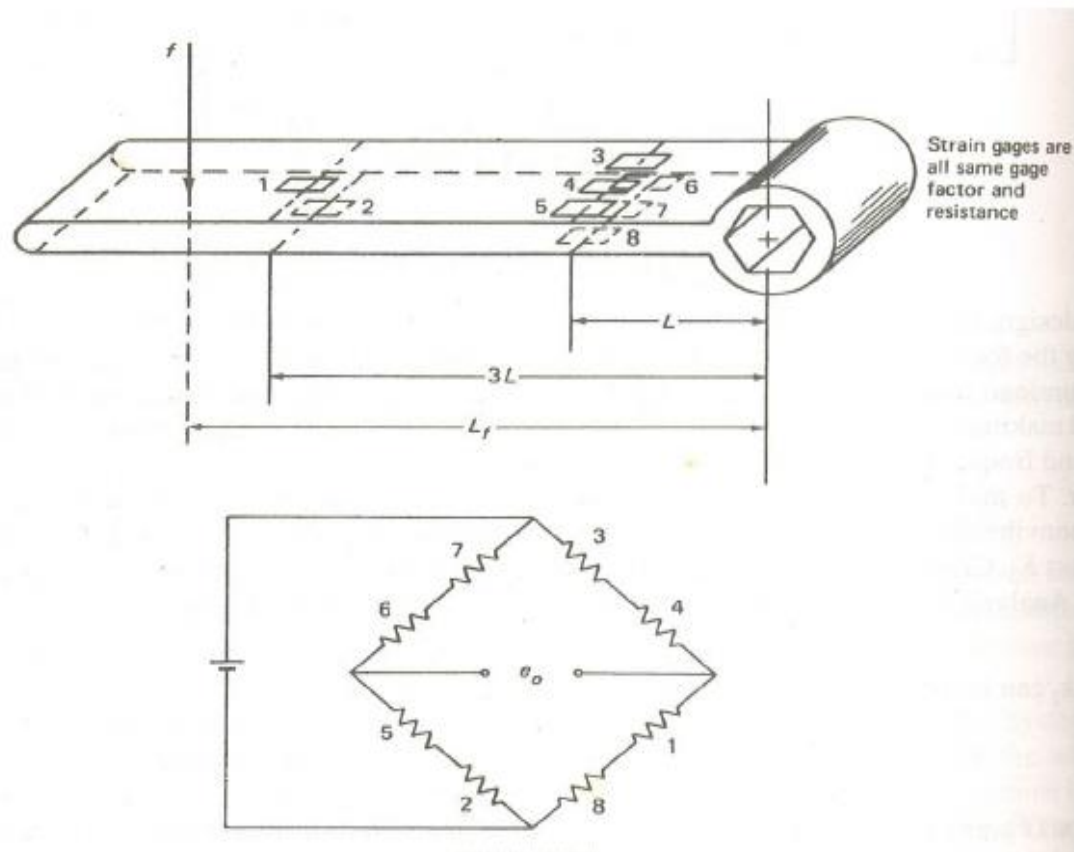


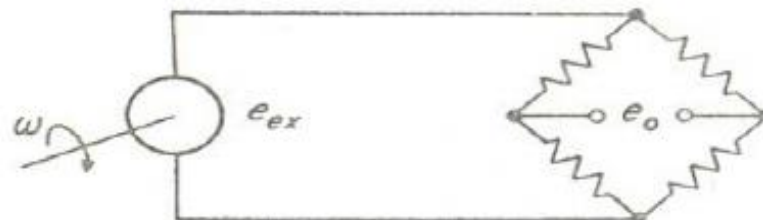
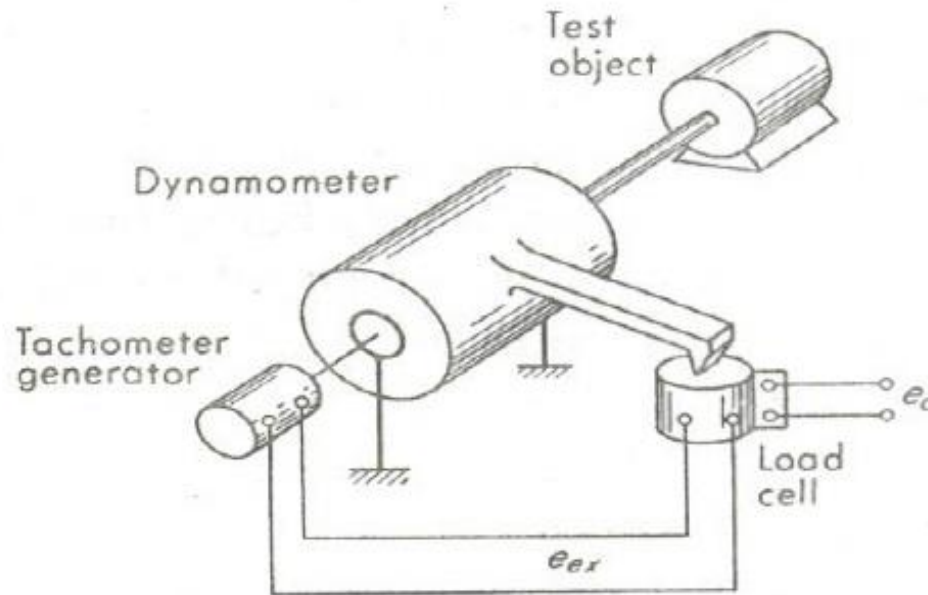
## Problem (Time to solve - 10 min)

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).



## Problem (Time to solve - 10 min)

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



An object with a volume of  $160\text{cc}$  is weighed on an equal arm balance. The standard mass required for balance is  $0.5\text{ kg}$  and has a volume of  $50\text{cc}$ . 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/°C is desired? Assume operation near 20 °C.

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

### Problem (Time to solve - 10 min)

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

### 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  $0.15\text{ }^{\circ}\text{C}/30\text{m}$ . The balloon radios temperature and altitude readings back to ground. At 3000m the balloon says the temperature is  $0^{\circ}\text{C}$ . What is the true altitude at  $0^{\circ}\text{C}$  occurs?