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**Q1** An electric circuit has a battery of EMF $E$ and it is connected to a resistor system as shown in the image below.

The resistor system alone is put in an adiabatic box (with circuit still connected) filled with ideal gas and containing a thermally conducting plate (plate shewn below) with coefficient of areal thermal expansion $\beta$ and heat capacity $c$. $R_2, R_5, R_3$ are fixed and $R_1, R_4$ are variable. Assume temperature change doesn't alter any of the macroscopically noticeable attributes of the wire and resistors.

-Find the condition on the resistors (all of them non-zero) for which the rate thermal expansion attains maximum.
- Find the equivalent resistance in such a condition described above.
- Draw how the plate will look like after a time $t$ and describe its size qualitatively.(Just the shape matters in drawing).

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**Q2** A regular tetrahedral massless frame whose side length is physically variable (with the constraint of the tetrahedron being regular) is dipped in a soap solution of surface tension $T$, taken outside and allowed to settle after a little wiggle.

The soap film is formed such that there is no volume in space that is enclosed by any of the surfaces soap film and all the soap film surfaces are planar. You may assume the configuration of the soap film without proof.

Now 4 point charges of charge $q$ are fixed at the vertices of the tetrahedron.

The system now sets into motion with the shape and nature of soap film being unaltered at all times.

- Describe the shape of the soap film you observe and your speculations on why it is formed this way. Also shew that the area spanned by the soap film is less than the total surface area of the tetrahedron.
- Find the side length of the tetrahedron for which the system attains mechanical equilibrium.

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**Q3** There are two semi-infinite plane mirrors inclined physically at a non-zero angle with inner surfaces being reflective.

- Prove that all lines of incident/reflected rays are tangential to a particular circle for any given

 

incident ray being incident on a reflective side. Assume that the incident ray lies on one of the normal planes to the mirrors.
- Try to guess the radius of circle by the parameters you can observe.

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