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We compute the Birkhoff normal form up to including order 4 at Lagrange's equilateral solution. The coefficients of the normal form are expressed in terms of two symmetric functions of the normalised masses. We show how the normal form of the spatial problem reduces to that of the planar problem and to that of the restricted problem. The normal form is used to determine the co-dimension one curves in normalised mass space for which the iso-energetic non-degeneracy condition is violated, and thus find a few special isolated cases in normalised mass space for which the elliptic equilateral solution of Lagrange can be non-linearly unstable. (Received September 25, 2017)