Quadratic Compatibility Theorem: Theorem 1 in the book Divine Proportions by Wildberger

The quadratic equations

$$(X-P1) = M$$

$$2(X-p2)=r2$$

are compatible precisely when

$$((p1-p2)^2-(m+r2))^2=4mr2$$

In this case, if p1 is not equal to p2 then there is a unique common solution

$$X = P1 + P2 - (r1 - r2)$$

2 $2(P1 - P2)$

Create a Mathematica function for unique common solution of a pair of compatible quadratic equations.

$$ln[1] = X[p1_, r1_, p2_, r2_] := ((p1 + p2) / 2) - (r1 - r2) / (2 (p1 - p2))$$

Substitute values for p1, r1, p2 and r2 from quadratic equations (1) and (2) above to compute the gadrea B.

The proof employs the quadratic compatibility theorem. We will show that equations (1) and (2) above are compatible since they meet the criteria for being compatible from the quadratic compatibility theorem.

Perform compatibility check:

$$ln[3]:=$$
 CompatibilityCheckLHS [p1_, r1_, p2_, r2_] := $((p1-p2)^2 - (r1+r2))^2$

$$ln[4]:=$$
 CompatibilityCheckRHS [p1_, r1_, p2_, r2_] := $4*r1*r2$

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ln[5]:= lhs = CompatibilityCheckLHS[q_{12} q_{23} S_2 + q_{34} q_{41} S_4,
                                                                                                                      4\ q_{12}\ q_{23}\ q_{34}\ q_{41}\ (1-S_1)\times (1-S_3) , q_{12}\ q_{41}\ S_1+q_{23}\ q_{34}\ S_3 , 4\ q_{12}\ q_{23}\ q_{34}\ q_{41}\ (1-S_2)\times (1-S_4) ]
Out[5]= \left(-4\ q_{12}\ q_{23}\ q_{34}\ q_{41}\ (1-S_1)\ \times\ (1-S_3)\ -\right.
                                                                                                                                          4\,q_{12}\,q_{23}\,q_{34}\,q_{41}\,\left(1-S_{2}\right)\,\times\,\left(1-S_{4}\right)\,+\,\left(-\,q_{12}\,q_{41}\,S_{1}\,+\,q_{12}\,q_{23}\,S_{2}\,-\,q_{23}\,q_{34}\,S_{3}\,+\,q_{34}\,q_{41}\,S_{4}\right)^{\,2}\right)^{\,2}
            ln[6]:= rhs = CompatibilityCheckRHS [q_{12} q_{23} S_2 + q_{34} q_{41} S_4,
                                                                                                                      4\,q_{12}\,q_{23}\,q_{34}\,q_{41}\,\left(1-S_{1}\right)\times\left(1-S_{3}\right),\,q_{12}\,q_{41}\,S_{1}+q_{23}\,q_{34}\,S_{3},\,4\,q_{12}\,q_{23}\,q_{34}\,q_{41}\,\left(1-S_{2}\right)\times\left(1-S_{4}\right)]
  Out[6]= 64 q_{12}^2 q_{23}^2 q_{34}^2 q_{41}^2 (1-S_1) \times (1-S_2) \times (1-S_3) \times (1-S_4)
            In[7]:= lhse = Expand[lhs]
  Out[7]= 64\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2 - 64\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_1 + 16\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_1^2 - 16\ q_{12}^3\ q_{23}\ q_{34}\ q_{41}^3\ S_1^2 +
                                                                                                     8\ q_{12}^{3}\ q_{23}\ q_{34}\ q_{41}^{3}\ S_{1}^{3}\ +\ q_{12}^{4}\ q_{41}^{4}\ S_{1}^{4}\ -\ 64\ q_{12}^{2}\ q_{23}^{2}\ q_{34}^{2}\ q_{41}^{2}\ S_{2}\ +\ 32\ q_{12}^{3}\ q_{23}^{2}\ q_{34}^{2}\ q_{41}^{2}\ S_{1}\ S_{2}\ +\ 32\ q_{12}^{2}\ q_{23}^{2}\ q_{34}^{2}\ q_{41}^{2}\ S_{1}\ S_{2}\ -\ 32\ q_{12}^{2}\ q_{23}^{2}\ q_{34}^{2}\ q_{41}^{2}\ S_{1}\ S_{2}\ +\ 32\ q_{12}^{2}\ q_{23}^{2}\ q_{34}^{2}\ q_{41}^{2}\ S_{1}\ S_{2}\ -\ 32\ q_{12}^{2}\ q_{23}^{2}\ q_{24}^{2}\ S_{1}\ S_{2}\ +\ 32\ q_{12}^{2}\ q_{23}^{2}\ q_{24}^{2}\ S_{1}\ S_{2}\ -\ 32\ q_{12}^{2}\ q_{23}^{2}\ q_{24}^{2}\ S_{1}\ S_{2}\ +\ 32\ q_{12}^{2}\ q_{23}^{2}\ q_{24}^{2}\ S_{1}\ S_{2}\ -\ q_{12}^{2}\ q_{23}^{2}\ q_{24}^{2}\ S_{1}\ S_{2}\ +\ 32\ q_{12}^{2}\ q_{23}^{2}\ q_{24}^{2}\ S_{1}\ S_{2}\ +\ 32\ q_{12}^{2}\ q_{23}^{2}\ q_{24}^{2}\ S_{1}\ S_{2}\ +\ 32\ q_{12}^{2}\ q_{23}^{2}\ q_{24}^{2}\ S_{1}\ S_{2}\ -\ q_{12}^{2}\ q_{23}^{2}\ q_{24}^{2}\ S_{1}\ S_{2}\ +\ 32\ q_{12}^{2}\ q_{12}^{2}\ q_{23}^{2}\ q_{24}^{2}\ S_{1}\ S_{2}\ +\ 32\ q_{12}^{2}\ q_{12}^{2}\ q_{12}^{2}\ q_{12}^{2}\ S_{2}\ q_{12}^{2}\ q_{12}
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                                                                                                     4\ q_{12}^{2}\ q_{23}^{3}\ q_{34}^{2}\ q_{41}\ S_{2}^{2}\ S_{3}\ S_{4}\ +\ 8\ q_{12}\ q_{23}^{3}\ q_{34}^{3}\ q_{41}\ S_{3}^{2}\ S_{4}\ -\ 16\ q_{12}\ q_{23}^{2}\ q_{34}^{3}\ q_{41}^{2}\ S_{3}^{2}\ S_{4}\ +\ 4\ q_{12}\ q_{23}^{2}\ q_{34}^{3}\ q_{41}^{2}\ S_{1}\ S_{3}^{2}\ S_{4}\ +\ q_{12}^{2}\ q_{23}^{2}\ q_{34}^{3}\ q_{41}^{2}\ S_{1}^{2}\ S_{2}^{2}\ S_{4}\ +\ q_{12}^{2}\ q_{23}^{2}\ q_{34}^{2}\ q_{41}^{2}\ S_{1}^{2}\ S_{2}^{2}\ S_{4}\ +\ q_{12}^{2}\ q_{23}^{2}\ q_{23}^{2}\ q_{24}^{2}\ S_{1}^{2}\ S_{2}^{2}\ S_{2}\ S_{3}\ S_{4}\ +\ q_{12}^{2}\ q_{23}^{2}\ q_{24}^{2}\ S_{1}^{2}\ S_{2}^{2}\ S_{2}\ S_{3}^{2}\ S_{4}\ +\ q_{12}^{2}\ q_{23}^{2}\ q_{24}^{2}\ S_{1}^{2}\ S_{2}^{2}\ S
                                                                                                  4\ q_{12}\ q_{23}^3\ q_{34}^3\ q_{41}\ S_2\ S_3^2\ S_4\ -\ 4\ q_{23}^3\ q_{34}^4\ q_{41}\ S_3^3\ S_4\ +\ 16\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_4^2\ -\ 16\ q_{12}\ q_{23}\ q_{34}^3\ q_{41}^3\ S_4^2\ -\ 16\ q_{12}\ q_{23}\ q_{23}^3\ q_{24}^3\ S_4^2\ -\ 16\ q_{12}\ q_{23}\ q_{24}^3\ q_{24}^3\ S_4^2\ -\ 16\ q_{12}\ q_{12}\ q_{12}^3\ q_{12
                                                                                                     16\ q_{12}^2\ q_{23}\ q_{34}^2\ q_{41}^3\ S_1\ S_4^2 + 8\ q_{12}\ q_{23}\ q_{34}^3\ q_{41}^3\ S_1\ S_4^2 + 6\ q_{12}^2\ q_{34}^2\ q_{41}^4\ S_1^2\ S_4^2 - 16\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_2\ S_4^2 + 6\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^4\ S_1^2\ S_4^2 - 16\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_2\ S_4^2 + 6\ q_{12}^2\ q_{23}^2\ q_{23}^2\ q_{24}^2\ q_{24}^2\ S_2\ S_4^2 + 6\ q_{12}^2\ q_{23}^2\ q_{24}^2\ q_{24}^2\ S_2\ S_4^2 + 6\ q_{12}^2\ q_{23}^2\ q_{24}^2\ q_{24}^2\ S_2\ S_4^2 + 6\ q_{12}^2\ q_{23}^2\ q_{24}^2\ q_{24}^2\ S_2\ S_2\ q_{24}^2\ S_2\ S_2\ q_{24}^2\ q_{24}^2\ S_2\ S_2\ q_{24}
                                                                                                  8 q_{12} q_{23} q_{34}^3 q_{41}^3 S_2 S_4^2 + 4 q_{12}^2 q_{23} q_{34}^2 q_{41}^3 S_1 S_2 S_4^2 + 6 q_{12}^2 q_{23}^2 q_{34}^2 q_{41}^2 S_2^2 S_4^2 - 16 q_{12} q_{23}^2 q_{34}^3 q_{41}^2 S_3 S_4^2 + 6 q_{12}^2 q_{23}^2 q_{34}^2 q_{41}^2 S_3 S_4^2 + 6 q_{12}^2 q_{23}^2 q_{24}^2 q_{24}^2 S_4^2 + 6 q_{12}^2 q_{24}^2 q_{24}^2 S_4^2 + 6 q_{12}^2 q_{24}^2 q_{24}^2 S_4^2 + 6 q_{12}^2 q_{24}^2 q_{24}^2 q_{24}^2 S_4^2 + 6 q_{12}^2 q_{24}^2 q_{24}^2 q_{24}^2 q_{24}^2 + 6 q_{12}^2 q_{24}^2 q_{24}^2 q_{24}^2 S_4^2 + 6 q_{12}^2 q_{24}^2 q_{24}^2 q_{24}^2 S_4^2 + 6 q_{12}^2 q_{24}^2 q_{24}^2 q_{24}^2 q_{24}^2 q_{24}^2 + 6 q_{12}^2 q_{24}^2 q_{24}^2 q_{24}^2 q_{24}^2 q_{24}^2 + 6 q_{12}^2 q_{24}^2 q_{24}^2 q_{24}^2 + 6 q_{12}^2 q_{24}^2 q_{24}^2 q_{24}^2 q_{24}^2 + 6 q_{12}^2 q_{24}^2 q_{24}^2 q_{24}^2 q_{24}^2 + 6 q_{12}^2 q_{24}^2 q_{24}^2 q_{24}^2 + 6 q_{12}^2 q_{24}^2 q_{24}^2 + 6 q_{12}^2 q_{24}^2 q_{24}^2 + 6 q_{12}^2 q_{24}^2 q_{24}^2 q_{24}^2 + 6 q_{12}^2 q_{24}^
                                                                                                     8 q_{12} q_{23} q_{34}^3 q_{41}^3 S_3 S_4^2 + 4 q_{12} q_{23} q_{34}^3 q_{41}^3 S_1 S_3 S_4^2 + 4 q_{12} q_{23}^2 q_{34}^3 q_{41}^2 S_2 S_3 S_4^2 + 6 q_{23}^2 q_{34}^4 q_{41}^2 S_3^2 S_4^2 + 6 q_{23}^2 q_{34}^4 q_{41}^2 S_3^2 S_4^2 + 6 q_{23}^2 q_{34}^2 q_{41}^2 S_5^2 S_5^2 S_5^2 + 6 q_{23}^2 q_{24}^2 S_5^2 S_5^2 S_5^2 S_5^2 + 6 q_{23}^2 q_{24}^2 S_5^2 S_
                                                                                                8\ q_{12}\ q_{23}\ q_{34}^3\ q_{41}^3\ S_4^3\ -4\ q_{12}\ q_{34}^3\ q_{41}^4\ S_1\ S_4^3\ -4\ q_{12}\ q_{23}\ q_{34}^3\ q_{41}^3\ S_2\ S_4^3\ -4\ q_{23}\ q_{34}^4\ q_{41}^3\ S_3\ S_4^3\ +\ q_{34}^4\ q_{41}^4\ S_4^4
            In[8]:= rhse = Expand[rhs]
  Out[8]= 64\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2 - 64\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_1 - 64\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_2 + 64\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_1\ S_2 - 64\ q_{12}^2\ q_{23}^2\ q_{24}^2\ q_{24}^2\ S_1\ S_2 - 64\ q_{12}^2\ q_
                                                                                                     64\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_3\ +\ 64\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_1\ S_3\ +\ 64\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_2\ S_3\ -\ 64\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_1\ S_2\ S_3\ -\ 64\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_1\ S_2\ S_3\ -\ 64\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_1\ S_2\ S_3\ -\ 64\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_1\ S_2\ S_3\ -\ 64\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_1\ S_2\ S_3\ -\ 64\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_1\ S_2\ S_3\ -\ 64\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_1\ S_2\ S_3\ -\ 64\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_1\ S_2\ S_3\ -\ 64\ q_{12}^2\ q_{23}^2\ q_{24}^2\ S_1\ S_2\ S_2\ S_3\ -\ 64\ q_{12}^2\ q_{23}^2\ q_{24}^2\ S_1\ S_2\ S_2\ S_3\ -\ 64\ q_{12}^2\ q_{23}^2\ q_{24}^2\ S_1\ S_2\ S_2\ S_3\ -\ 64\ q_{12}^2\ q_{23}^2\ q_{24}^2\ S_1\ S_2\ S_2\ S_3\ -\ 64\ q_{12}^2\ q_{23}^2\ q_{24}^2\ S_1\ S_2\ S_2\ S_3\ -\ 64\ q_{12}^2\ q_{23}^2\ q_{24}^2\ S_2\ S_2\ S_3\ -\ 64\ q_{12}^2\ q_{23}^2\ q_{24}^2\ S_1\ S_2\ S_2\ S_2\ S_2\ S_3\ -\ 64\ q_{12}^2\ q_{1
                                                                                                  64\ q_{12}^{2}\ q_{23}^{2}\ q_{34}^{2}\ q_{41}^{2}\ S_{4}+64\ q_{12}^{2}\ q_{23}^{2}\ q_{34}^{2}\ q_{41}^{2}\ S_{1}\ S_{4}+64\ q_{12}^{2}\ q_{23}^{2}\ q_{34}^{2}\ q_{41}^{2}\ S_{2}\ S_{4}-64\ q_{12}^{2}\ q_{23}^{2}\ q_{34}^{2}\ q_{41}^{2}\ S_{1}\ S_{2}\ S_{4}+64\ q_{12}^{2}\ q_{23}^{2}\ q_{34}^{2}\ q_{41}^{2}\ S_{2}\ S_{4}-64\ q_{12}^{2}\ q_{23}^{2}\ q_{34}^{2}\ q_{41}^{2}\ S_{1}\ S_{2}\ S_{4}+64\ q_{12}^{2}\ q_{23}^{2}\ q_{24}^{2}\ S_{1}\ S_{2}\ S_{4}+64\ q_{12}^{2}\ q_{23}^{2}\ q_{24}^{2}\ S_{1}\ S_{2}\ S_{3}+64\ q_{12}^{2}\ q_{23}^{2}\ q_{24}^{2}\ S_{1}\ S_{2}\ S_{3}+64\ q_{12}^{2}\ q_{12}^{2}\
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 $64\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_3\ S_4\ -\ 64\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_1\ S_3\ S_4\ -\ 64\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_2\ S_3\ S_4\ +\ 64\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_1\ S_2\ S_3\ S_4$

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In[9]:= res = 1hse - rhse
              Out[9]= 16 q_{12}^2 q_{23}^2 q_{34}^2 q_{41}^2 S_1^2 - 16 q_{12}^3 q_{23} q_{34} q_{41}^3 S_1^2 + 8 q_{12}^3 q_{23} q_{34} q_{41}^3 S_1^3 + q_{12}^4 q_{41}^4 S_1^4 + 32 q_{12}^3 q_{23}^2 q_{34} q_{41}^2 S_1 S_2 - q_{12}^2 q_{1
                                                                                                                               32\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_1\ S_2\ -\ 16\ q_{12}^3\ q_{23}^2\ q_{34}\ q_{41}^2\ S_1^2\ S_2\ +\ 8\ q_{12}^3\ q_{23}\ q_{34}\ q_{41}^3\ S_1^2\ S_2\ -\ 4\ q_{12}^4\ q_{23}\ q_{41}^3\ S_1^3\ S_2\ -\ q_{41}^4\ q_{42}^2\ q_{42}^3\ q_{41}^3\ S_1^3\ S_2\ -\ q_{42}^4\ q_{42}^3\ q_{42}^3\ S_1^3\ S_2\ -\ q_{42}^4\ q_{42}^3\ 
                                                                                                                               16\ q_{12}^3\ q_{23}^3\ q_{34}\ q_{41}\ S_2^2\ +\ 16\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_2^2\ +\ 8\ q_{12}^3\ q_{23}^3\ q_{34}\ q_{41}\ S_1\ S_2^2\ -\ 16\ q_{12}^3\ q_{23}^2\ q_{34}\ q_{41}^2\ S_1\ S_2^2\ +\ 16\ q_{12}^3\ q_{23}^3\ q_{34}^2\ q_{24}^3\ S_1\ S_2^2\ +\ 16\ q_{12}^3\ q_{23}^3\ q_{34}^3\ q_{24}^3\ S_1\ S_2^2\ +\ 16\ q_{12}^3\ q_{23}^3\ q_{24}^3\ q_{24}^3\ S_1\ S_2^2\ +\ 16\ q_{12}^3\ q_{24}^3\ q_{24}^3\ q_{24}^3\ S_1\ S_2^2\ +\ 16\ q_{12}^3\ q_{24}^3\ q_{24}^3\ q_{24}^3\ S_1\ S_2^2\ +\ 16\ q_{12}^3\ q_{24}^3\ q_{24}^3
                                                                                                                               6\ q_{12}^4\ q_{23}^2\ q_{41}^2\ S_1^2\ S_2^2\ +\ 8\ q_{12}^3\ q_{23}^3\ q_{34}\ q_{41}\ S_2^3\ -\ 4\ q_{12}^4\ q_{23}^3\ q_{41}\ S_1\ S_2^3\ +\ q_{12}^4\ q_{23}^4\ S_2^4\ -\ 16\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_1^2\ S_3\ +\ q_{12}^4\ q_{12}^4\ S_2^4\ S_2^4\ -\ 16\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_1^2\ S_3\ +\ q_{12}^2\ S_3\ +\ q_{12}^2\ q_{12}
                                                                                                                            8\ q_{12}^{3}\ q_{23}\ q_{34}\ q_{41}^{3}\ S_{1}^{2}\ S_{3}\ -\ 4\ q_{12}^{3}\ q_{23}\ q_{34}\ q_{41}^{3}\ S_{1}^{3}\ S_{3}\ +\ 32\ q_{12}^{2}\ q_{23}^{3}\ q_{34}^{2}\ q_{41}\ S_{2}\ S_{3}\ -\ 32\ q_{12}^{2}\ q_{23}^{2}\ q_{34}^{2}\ q_{41}^{2}\ S_{2}\ S_{3}\ -\ 32\ q_{12}^{2}\ q_{23}^{2}\ q_{24}^{2}\ q_{24}^{2}\ S_{2}\ S_{3}\ -\ 32\ q_{12}^{2}\ q_{23}^{2}\ q_{24}^{2}\ q_{24}^{2}\ S_{2}\ S_{3}\ -\ 32\ q_{12}^{2}\ q_{12}^{2}\ q_{23}^{2}\ q_{24}^{2}\ q_{24}^{2}\ S_{2}\ S_{3}\ -\ 32\ q_{12}^{2}\ q_{24}^{2}\ q_{24}^{2}\ S_{2}\ S_{3}\ -\ 32\ q_{12}^{2}\ q_{12}^{2}\ q_{24}^{2}\ q_{24}^{2}\ S_{2}\ S_{3}\ -\ 32\ q_{12}^{2}\ q_{12}^{2}\ q_{12}^{2}\ q_{12}^{2}\ q_{12}^{2}\ S_{3}\ -\ 32\ q_{12}^{2}\ q_{12}^{2}\ q_{12}^{2}\ q_{12}^{2}\ S_{3}\ -\ 32\ q_{12}^{2}\ q_{12}^{2}\ q_{12}^{2}\ q_{12}^{2}\ q_{12}^{2}\ S_{3}\ -\ 32\ q_{12}^{2}\ q_{12}^{2}\ q_{12}^{2}\ q_{12}^{2}\ q_{12}^{2}\ S_{3}\ -\ 32\ q_{12}^{2}\ q_{12}^{2}\ q_{12}^{2}\ q_{12}^{2}\ S_{3}\ -\ 32\ q_{12}^{2}\ q_{12}^{2}\ q_{12}^{2}\ q_{12}^{2}\ q_{12}^{2}\ S_{3}\ -\ 32\ q_{12}^{2}\ q_{12}^{2}\
                                                                                                                               16\ q_{12}^2\ q_{23}^3\ q_{34}^2\ q_{41}\ S_1\ S_2\ S_3\ -\ 16\ q_{12}^3\ q_{23}^2\ q_{34}\ q_{41}^2\ S_1\ S_2\ S_3\ +\ 48\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_1\ S_2\ S_3\ +\ 4\ q_{12}^3\ q_{23}^2\ q_{34}\ q_{41}^2\ S_1^2\ S_2\ S_3\ +\ 4\ q_{12}^3\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_1\ S_2\ S_3\ +\ 4\ q_{12}^3\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_1\ S_2\ S_3\ +\ 4\ q_{12}^3\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_1\ S_2\ S_3\ +\ 4\ q_{12}^3\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_1\ S_2\ S_3\ +\ 4\ q_{12}^3\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_1\ S_2\ S_3\ +\ 4\ q_{12}^3\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_1\ S_2\ S_3\ +\ 4\ q_{12}^3\ q_{23}^2\ q_{34}^2\ q_{23}^2\ q_{34}^2\ q_{23}^2\ q_{34}^2\ q_{23}^2\ q_
                                                                                                                               8\ q_{12}^{3}\ q_{23}^{3}\ q_{34}\ q_{41}\ S_{2}^{2}\ S_{3}-16\ q_{12}^{2}\ q_{23}^{3}\ q_{34}^{2}\ q_{41}\ S_{2}^{2}\ S_{3}+4\ q_{12}^{3}\ q_{23}^{3}\ q_{34}\ q_{41}\ S_{1}\ S_{2}^{2}\ S_{3}-4\ q_{12}^{3}\ q_{23}^{4}\ q_{34}\ S_{2}^{3}\ S_{3}-4\ q_{12}^{3}\ q_{23}^{4}\ q_{24}\ S_{2}^{3}\ S_{3}-4\ q_{12}^{3}\ q_{23}^{3}\ q_{24}^{3}\ q_{24}^{3}\ S_{2}^{3}-4\ q_{12}^{3}\ q_{24}^{3}\ q_{24}^{3}\ S_{2}^{3}-4\ q_{12}^{3}\ q_{24}^{3}\ 
                                                                                                                               16\ q_{12}\ q_{23}^3\ q_{34}^3\ q_{41}\ S_3^2\ +\ 16\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_3^2\ +\ 8\ q_{12}\ q_{23}^3\ q_{34}^3\ q_{41}\ S_1\ S_3^2\ -\ 16\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_1\ S_3^2\ +\ 10\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_1\ S_3^2\ +\ 10\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_1\ S_3^2\ +\ 10\ q_{12}^2\ q_{23}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_1\ S_3^2\ +\ 10\ q_{12}^2\ q_{23}^2\ q_{23}^2\ q_{24}^2\ q_{24}^2\ S_1\ S_3^2\ +\ 10\ q_{12}^2\ q_{23}^2\ q_{24}^2\ q_{24}^2\ S_1\ S_3^2\ +\ 10\ q_{12}^2\ q_{12}^2\ q_{12}^2\ q_{13}^2\ q_{24}^2\ S_1\ S_3^2\ +\ 10\ q_{12}^2\ q_{13}^2\ q_{13}^2\ q_{14}^2\ S_1\ S_3^2\ +\ 10\ q_{12}^2\ q_{14}^2\ S_1\ S_2^2\ +\ 10\ q_{12}^2\ q_{14}^2\ S_1\ S_2^2\ +\ 10\ q_{12}^2\ q_{13}^2\ q_{14}^2\ S_1\ S_2^2\ +\ 10\ q_{12}^2\ q_{13}^2\ q_{14}^2\ S_1\ S_2^2\ +\ 10\ q_{12}^2\ q_{13}^2\ q_{14}^2\ S_1\ S_2^2\ +\ 10\ q_{12}^2\ q_{14}^2\ S_1\ S_2^2\ +\ 10\ q_{12}^2\ q_{14}^2\ S_1\ S_2^2\ +\ 10\ q_{14}^2\ q_{14}^2\ S_1\ S_2^2\ q_{14}^2\ S_1\ S_2^2\ +\ 10\ q_{14}^2\ q_{14}^2\ S_1\ S_2^2\ +\ 10\ q_{14}^2\ q_{14}^2\ q_{14}^2\ q_{14}^2\ q_{14}^2\ S_1\ S_2^2\ +\ 10\ q_{14}^2\ q_{
                                                                                                                            6\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_1^2\ S_3^2\ -\ 16\ q_{12}^2\ q_{23}^3\ q_{34}^2\ q_{41}\ S_2\ S_3^2\ +\ 8\ q_{12}\ q_{23}^3\ q_{34}^3\ q_{41}\ S_2\ S_3^2\ +\ 4\ q_{12}^2\ q_{23}^3\ q_{34}^2\ q_{41}\ S_1\ S_2\ S_3^2\ +\ q_{12}^2\ q_{23}^3\ q_{34}^3\ q_{41}\ S_1\ S_2\ S_3^2\ +\ q_{12}^2\ q_{23}^3\ q_{24}^3\ q_{24}\ S_1\ S_2\ S_3^2\ +\ q_{12}^2\ q_{12}
                                                                                                                            6\ q_{12}^{2}\ q_{23}^{4}\ q_{34}^{2}\ S_{2}^{2}\ S_{3}^{2}\ +\ 8\ q_{12}\ q_{23}^{3}\ q_{34}^{3}\ q_{41}\ S_{3}^{3}\ -\ 4\ q_{12}\ q_{23}^{3}\ q_{34}^{3}\ q_{41}\ S_{1}\ S_{3}^{3}\ -\ 4\ q_{12}\ q_{23}^{4}\ q_{34}^{3}\ S_{2}\ S_{3}^{3}\ +\ q_{23}^{4}\ q_{34}^{4}\ S_{3}^{4}\ -\ q_{24}^{4}\ q_{24}^{4}\ +\ q_{24}^{4}\ q_{24}^{4}\ S_{3}^{4}\ -\ q_{24}^{4}\ q_{24}^{4}\ +\ q_{24}^{4}\ q_{24}^{4}\ +\ q_{24}^{4}\ q_{24}^{4}\ +\ q_{24}^{4}\ q_{24}^{4}\ +\ q_{24}^{4}\ +\ q_{24}^{4}\ q_{24}^{4}\ +\ q_{24}^{4}\ +\ q_{24}^{4}\ q_{24}^{4}\ +\ q_{24}
                                                                                                                               32\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_1\ S_4\ +\ 32\ q_{12}^2\ q_{23}\ q_{34}^2\ q_{41}^3\ S_1\ S_4\ +\ 8\ q_{12}^3\ q_{23}\ q_{34}\ q_{41}^3\ S_1^2\ S_4\ -\ 16\ q_{12}^2\ q_{23}\ q_{34}^2\ q_{41}^3\ S_1^2\ S_4\ -\ 16\ q_{12}^2\ q_{23}\ q_{34}^2\ q_{41}^3\ S_1^2\ S_4\ -\ 16\ q_{12}^2\ q_{23}\ q_{34}^2\ q_{31}^3\ S_1^2\ S_4\ -\ 16\ q_{12}^2\ q_{23}\ q_{34}^2\ q_{31}^2\ S_1^2\ S_4\ -\ 16\ q_{12}^2\ q_{23}\ q_{23}^2\ q_{23}^2
                                                                                                                               4\ q_{12}^{3}\ q_{34}\ q_{41}^{4}\ S_{1}^{3}\ S_{4}-16\ q_{12}^{3}\ q_{23}^{2}\ q_{34}\ q_{41}^{2}\ S_{1}\ S_{2}\ S_{4}+48\ q_{12}^{2}\ q_{23}^{2}\ q_{34}^{2}\ q_{41}^{2}\ S_{1}\ S_{2}\ S_{4}-16\ q_{12}^{2}\ q_{23}^{2}\ q_{34}^{2}\ q_{41}^{3}\ S_{1}\ S_{2}\ S_{4}+100\ q_{12}^{2}\ q_{23}^{2}\ q_{24}^{2}\ S_{1}\ S_{2}\ S_{2}\ S_{4}+100\ q_{12}^{2}\ q_{23}^{2}\ q_{34}^{2}\ q_{41}^{2}\ S_{1}\ S_{2}\ S_{4}+100\ q_{12}^{2}\ q_{23}^{2}\ q_{34}^{2}\ q_{41}^{2}\ S_{1}\ S_{2}\ S_{4}+100\ q_{12}^{2}\ q_{23}^{2}\ q_{34}^{2}\ q_{41}^{2}\ S_{1}\ S_{2}\ S_{3}+100\ q_{12}^{2}\ q_{23}^{2}\ q_{24}^{2}\ S_{1}\ S_{2}\ S_{3}+100\ q_{12}^{2}\ q_{23}^{2}\ q_{24}^{2}\ S_{1}\ S_{2}\ S_{3}+100\ q_{12}^{2}\ q_{12}^{2}\ q_{13}^{2}\ q_{14}^{2}\ S_{1}\ S_{2}\ S_{3}+100\ q_{12}^{2}\ q_{13}^{2}\ q_{14}^{2}\ S_{1}\ S_{2}\ S_{3}+100\ q_{12}^{2}\ q_{13}^{2}\ q_{13}^{2}\ q_{14}^{2}\ S_{1}\ S_{2}\ S_{3}+100\ q_{12}^{2}\ q_{13}^{2}\ q_{14}^{2}\ S_{1}\ S_{2}\ S_{3}+100\ q_{12}^{2}\ q_{13}^{2}\ q_{14}^{2}\ q_{14}^{2}\ S_{1}\ S_{2}\ S_{3}+100\ q_{14}^{2}\ S_{1}\ S_{2}\ S_{3}+100\ q_{14}^{2}\ q_{14}^{2}\ S_{1}\ S_{2}\ S_{3}+100\ q_{14}^{2}\ S_{15}\ S_{2}\ S_{2}\ S_{3}+100\ q_{14}^{2}\ S_{15}\ S_{2}\ S_{2}\ S_{2}+100\ q_{14}^{2}\ S_{15}\ S_{2}\ S_{2}+100\ q_{14}^{2}\ S_{2}\ S_{2}+100\ q_{14}^{2}\ S_{2}+100\ q_{14}^{2}\ S_{2}+100\ q_{14}^{2}\ S_{2}+1000\ q_{14}^{2}\ S_{
                                                                                                                         4\ q_{12}^{3}\ q_{23}\ q_{34}\ q_{41}^{3}\ S_{1}^{2}\ S_{2}\ S_{4}\ +\ 8\ q_{12}^{3}\ q_{23}^{3}\ q_{34}\ q_{41}\ S_{2}^{2}\ S_{4}\ -\ 16\ q_{12}^{2}\ q_{23}^{2}\ q_{34}^{2}\ q_{41}^{2}\ S_{2}^{2}\ S_{4}\ +\ 4\ q_{12}^{3}\ q_{23}^{2}\ q_{34}\ q_{41}^{2}\ S_{1}\ S_{2}^{2}\ S_{4}\ -\ 16\ q_{12}^{2}\ q_{23}^{2}\ q_{34}^{2}\ q_{41}^{2}\ S_{2}^{2}\ S_{4}\ +\ 4\ q_{12}^{3}\ q_{23}^{2}\ q_{34}\ q_{41}^{2}\ S_{1}\ S_{2}^{2}\ S_{4}\ -\ 16\ q_{12}^{2}\ q_{23}^{2}\ q_{34}^{2}\ q_{41}^{2}\ S_{2}^{2}\ S_{4}\ +\ 4\ q_{12}^{3}\ q_{23}^{2}\ q_{34}^{2}\ q_{41}^{2}\ S_{1}\ S_{2}^{2}\ S_{4}\ -\ 16\ q_{12}^{2}\ q_{23}^{2}\ q_{23}^{2}\ q_{24}^{2}\ q_{23}^{2}\ q_{24}^{2}\ q_{24}^{2}\ S_{2}^{2}\ S_{4}\ +\ 4\ q_{12}^{3}\ q_{23}^{2}\ q_{24}^{2}\ q_{24}^{2}\ S_{1}^{2}\ S_{2}^{2}\ S_{4}\ +\ 4\ q_{12}^{3}\ q_{23}^{2}\ q_{24}^{2}\ q_{24}^{2}\ S_{1}^{2}\ S_{2}^{2}\ S_{4}\ +\ 4\ q_{12}^{3}\ q_{23}^{2}\ q_{24}^{2}\ q_{24}^{2}\ S_{1}^{2}\ S_{2}^{2}\ S_{2}\ S_{2}\ S_{2}^{2}\ S_{2}\ S_{2}^{2}\ S_{
                                                                                                                               4\ q_{12}^{3}\ q_{23}^{3}\ q_{34}\ q_{41}\ S_{2}^{3}\ S_{4}-32\ q_{12}^{2}\ q_{23}^{2}\ q_{34}^{2}\ q_{41}^{2}\ S_{3}\ S_{4}+32\ q_{12}\ q_{23}^{2}\ q_{34}^{3}\ q_{41}^{2}\ S_{3}\ S_{4}+48\ q_{12}^{2}\ q_{23}^{2}\ q_{34}^{2}\ q_{41}^{2}\ S_{1}\ S_{3}\ S_{4}-32\ q_{12}^{2}\ q_{23}^{2}\ q_{34}^{2}\ q_{41}^{2}\ S_{3}\ S_{4}+48\ q_{12}^{2}\ q_{23}^{2}\ q_{34}^{2}\ q_{41}^{2}\ S_{1}\ S_{3}\ S_{4}-32\ q_{12}^{2}\ q_{23}^{2}\ q_{34}^{2}\ q_{24}^{2}\ S_{1}\ S_{2}\ S_{3}\ S_{4}+48\ q_{12}^{2}\ q_{23}^{2}\ q_{24}^{2}\ q_{24}^{2}\ S_{1}\ S_{2}\ S_{3}\ S_{4}+48\ q_{12}^{2}\ q_{12}^{2}\ q_{12}^{2}\ q_{12}^{2}\ q_{12}^{2}\ q_{13}^{2}\ q_{12}^{2}\ q_{12}^{2}\ q_{13}^{2}\ q_{12}^{2}\ q_{12}^{2}\ q_{13}^{2}\ q_{12}^{2}\ q_{13}^{2}\ q_{13}^{2}\ q_{12}^{2}\ q_{13}^{2}\ q_{13}^{2}\ q_{12}^{2}\ q_{13}^{2}\ 
                                                                                                                               16\ q_{12}\ q_{23}^2\ q_{34}^3\ q_{41}^2\ S_1\ S_3\ S_4 - 16\ q_{12}^2\ q_{23}\ q_{34}^2\ q_{41}^3\ S_1\ S_3\ S_4 + 4\ q_{12}^2\ q_{23}\ q_{34}^2\ q_{41}^3\ S_1^2\ S_3\ S_4 - 16\ q_{12}^2\ q_{23}^3\ q_{34}^2\ q_{41}\ S_2\ S_3\ S_4 + 4\ q_{12}^2\ q_{23}\ q_{34}^2\ q_{41}^3\ S_1^2\ S_3\ S_4 - 16\ q_{12}^2\ q_{23}^3\ q_{34}^2\ q_{41}\ S_2\ S_3\ S_4 + 4\ q_{12}^2\ q_{23}^2\ q_{34}^3\ S_1^2\ S_3\ S_4 - 16\ q_{12}^2\ q_{23}^3\ q_{24}^3\ q_{41}^3\ S_1^2\ S_3\ S_4 + 4\ q_{12}^2\ q_{23}^3\ q_{34}^3\ q_{41}^3\ S_1^2\ S_3\ S_4 - 16\ q_{12}^2\ q_{23}^3\ q_{24}^3\ q_{41}^3\ S_1^2\ S_3\ S_4 + 4\ q_{12}^2\ q_{23}^3\ q_{34}^3\ q_{34}^3\ S_1^2\ S_3\ S_4 - 16\ q_{12}^2\ q_{23}^3\ q_{24}^3\ q_{24}^3\ S_1^2\ S_3\ S_4 + 4\ q_{12}^2\ q_{23}^3\ q_{24}^3\ q_{24}^3\ S_1^2\ S_3\ S_4 - 16\ q_{12}^2\ q_{23}^3\ q_{24}^3\ q_{24}^3\ S_1^2\ S_3\ S_4 + 4\ q_{12}^2\ q_{23}^3\ q_{24}^3\ q_{24}^3\ S_1^2\ S_3\ S_4 + 4\ q_{12}^2\ q_{23}^3\ q_{24}^3\ q_{24}^3\ S_1^2\ S_3\ S_4 + 4\ q_{12}^2\ q_{23}^3\ q_{24}^3\ q_{24}^3\ S_1^2\ S_3\ S_4 + 4\ q_{12}^2\ q_{23}^3\ q_{24}^3\ q_{24}^3\ S_1^2\ S_3\ S_4 + 8\ q_{12}^2\ q_{12}^2\ q_{12}^3\ q_{12
                                                                                                                               48\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_2\ S_3\ S_4-16\ q_{12}\ q_{23}^2\ q_{34}^3\ q_{41}^2\ S_2\ S_3\ S_4-40\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_1\ S_2\ S_3\ S_4+
                                                                                                                            4\ q_{12}^{2}\ q_{23}^{3}\ q_{34}^{2}\ q_{41}\ S_{2}^{2}\ S_{3}\ S_{4}\ +\ 8\ q_{12}\ q_{23}^{3}\ q_{34}^{3}\ q_{41}\ S_{3}^{2}\ S_{4}\ -\ 16\ q_{12}\ q_{23}^{2}\ q_{34}^{3}\ q_{41}^{2}\ S_{3}^{2}\ S_{4}\ +\ 4\ q_{12}\ q_{23}^{2}\ q_{34}^{3}\ q_{41}^{2}\ S_{1}\ S_{3}^{2}\ S_{4}\ +\ q_{12}^{2}\ q_{23}^{3}\ q_{34}^{2}\ q_{41}^{2}\ S_{1}^{2}\ S_{2}^{2}\ S_{3}\ S_{4}\ +\ q_{12}^{2}\ q_{23}^{2}\ q_{34}^{2}\ q_{41}^{2}\ S_{1}^{2}\ S_{2}^{2}\ S_{3}\ S_{4}\ +\ q_{12}^{2}\ q_{23}^{2}\ q_{34}^{2}\ q_{41}^{2}\ S_{1}^{2}\ S_{2}^{2}\ S_{2}\ S_{3}\ S_{4}\ +\ q_{12}^{2}\ q_{23}^{2}\ q_{34}^{2}\ q_{41}^{2}\ S_{1}^{2}\ S_{2}^{2}\ S_{2}\ S_{3}\ S_{4}\ +\ q_{12}^{2}\ q_{23}^{2}\ q_{23}^{2}\ q_{24}^{2}\ S_{1}^{2}\ S_{2}^{2}\ S_{2}\ S_{2}\ S_{2}\ S_{2}^{2}\ S_{2}\ S_{2}^{2}\ S_{
                                                                                                                               4 q_{12} q_{23}^3 q_{34}^3 q_{41} S_2 S_3^2 S_4 - 4 q_{23}^3 q_{34}^4 q_{41} S_3^3 S_4 + 16 q_{12}^2 q_{23}^2 q_{34}^2 q_{41}^2 S_4^2 - 16 q_{12} q_{23} q_{34}^3 q_{41}^3 S_4^2 - 16 q_{12} q_{13} q_{13}^3 q_{14}^3 S_4^2 - 16 q_{12} q_{13} q_{14}^3 q_{14}^3 S_4^2 - 16 q_{12} q_{13}^3 q_{14}^3 q_{14}^3 S_4^3 - 16 q_{12}^3 q_{14}^3 q_{14}^3 S_4^3 - 16 q_{12}^3 q_{14}^3 S_4^3 - 16 q_{12}^3 q_{14}^3 q_{14}^3 S_4^3 - 16 q_{12}^3 q_{
                                                                                                                               16\ q_{12}^2\ q_{23}\ q_{34}^2\ q_{41}^3\ S_1\ S_4^2 + 8\ q_{12}\ q_{23}\ q_{34}^3\ q_{41}^3\ S_1\ S_4^2 + 6\ q_{12}^2\ q_{34}^2\ q_{41}^4\ S_1^2\ S_4^2 - 16\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_2\ S_4^2 + 6\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^4\ S_1^2\ S_4^2 - 16\ q_{12}^2\ q_{23}^2\ q_{34}^2\ q_{41}^2\ S_2\ S_4^2 + 6\ q_{12}^2\ q_{23}^2\ q_{23}^2\ q_{24}^2\ q_{24}^2\ S_2\ S_4^2 + 6\ q_{12}^2\ q_{23}^2\ q_{24}^2\ q_{24}^2\ S_2\ S_4^2 + 6\ q_{12}^2\ q_{23}^2\ q_{24}^2\ q_{24}^2\ S_2\ S_4^2 + 6\ q_{12}^2\ q_{23}^2\ q_{24}^2\ q_{24}^2\ S_2\ S_2\ q_{24}^2\ S_2\ S_2\ q_{24}^2\ q_{24}^2\ S_2\ S_2\ q_{24}
                                                                                                                            8 q_{12} q_{23} q_{34}^3 q_{41}^3 S_2 S_4^2 + 4 q_{12}^2 q_{23} q_{34}^2 q_{41}^3 S_1 S_2 S_4^2 + 6 q_{12}^2 q_{23}^2 q_{34}^2 q_{41}^2 S_2^2 S_4^2 - 16 q_{12} q_{23}^2 q_{34}^3 q_{41}^2 S_3 S_4^2 + 6 q_{12}^2 q_{23}^2 q_{34}^2 q_{41}^2 S_3 S_4^2 + 6 q_{12}^2 q_{12}^
                                                                                                                            8\ q_{12}\ q_{23}\ q_{34}^3\ q_{41}^3\ S_3\ S_4^2\ +\ 4\ q_{12}\ q_{23}^3\ q_{34}^3\ q_{41}^3\ S_1\ S_3\ S_4^2\ +\ 4\ q_{12}\ q_{23}^2\ q_{34}^3\ q_{41}^2\ S_2\ S_3\ S_4^2\ +\ 6\ q_{23}^2\ q_{34}^4\ q_{41}^2\ S_3^2\ S_4^2\ +
                                                                                                                            8 \ q_{12} \ q_{23} \ q_{34}^3 \ q_{41}^3 \ S_4^3 - 4 \ q_{12} \ q_{34}^3 \ q_{41}^4 \ S_1 \ S_4^3 - 4 \ q_{12} \ q_{23} \ q_{34}^3 \ q_{41}^3 \ S_2 \ S_4^3 - 4 \ q_{23} \ q_{44}^4 \ S_3 \ S_4^3 + q_{34}^4 \ q_{41}^4 \ S_4^4
           ln[10]:= a_1 = \{x_1, y_1, z_1\}
                                                                                                     a_2 = \{x_2, y_2, z_2\}
                                                                                                     a_3 = \{x_3, y_3, z_3\}
                                                                                                     a_4 = \{x_4, y_4, z_4\}
Out[10]= \{X_1, Y_1, Z_1\}
Out[11]= \{x_2, y_2, z_2\}
Out[12]= \{X_3, Y_3, Z_3\}
Out[13]= \{x_4, y_4, z_4\}
        In[14]:= J[a1_, a2_] :=
                                                                                                                                 \{a1[2] \times a2[3] - a1[3] \times a2[2], a1[3] \times a2[1] - a1[1] \times a2[3], a1[1] \times a2[2] - a1[2] \times a2[1] \}
           log_{15} = quadrance[a1_, a2_] := 1 - (a1[1] \times a2[1] + a1[2] \times a2[2] + a1[3] \times a2[3])^2 / a1[3] + a1[3] \times a2[3] + a1[3] + a1
                                                                                                                                                                              ((a1[1] \times a1[1] + a1[2] \times a1[2] + a1[3] \times a1[3]) \times
                                                                                                                                                                                                                         (a2[1] \times a2[1] + a2[2] \times a2[2] + a2[3] \times a2[3])
        lo[16] = spread[11_, 12_] := 1 - (11[1] \times 12[1] + 11[2] \times 12[2] + 11[3] \times 12[3])^2 / (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) = 10 - (10.16) =
                                                                                                                                                                            (\,(11[\![1]\!]\times11[\![1]\!]+11[\![2]\!]\times11[\![2]\!]+11[\![3]\!]\times11[\![3]\!])\,\times\\
                                                                                                                                                                                                                         (12[1] \times 12[1] + 12[2] \times 12[2] + 12[3] \times 12[3])
```

$$ln[17]:= q_{12} = quadrance[a_1, a_2]$$

$$q_{23} = quadrance[a_2, a_3]$$

$$q_{34} = quadrance[a_3, a_4]$$

$$q_{41} = quadrance[a_4, a_1]$$

$$\text{Out[17]= } 1 - \frac{\left(x_1\,x_2 + y_1\,y_2 + z_1\,z_2\right)^2}{\left(x_1^2 + y_1^2 + z_1^2\right)\,\left(x_2^2 + y_2^2 + z_2^2\right)}$$

$$\text{Out[18]= } 1 - \frac{\left(x_2\,x_3 + y_2\,y_3 + z_2\,z_3\right)^2}{\left(x_2^2 + y_2^2 + z_2^2\right)\,\left(x_3^2 + y_3^2 + z_3^2\right)}$$

$$\text{Out[19]= } 1 - \frac{\left(x_3 \; x_4 + y_3 \; y_4 + z_3 \; z_4\right)^2}{\left(x_3^2 + y_3^2 + z_3^2\right) \; \left(x_4^2 + y_4^2 + z_4^2\right)}$$

$$\text{Out[20]= } 1 - \frac{\left(x_1 \, x_4 + y_1 \, y_4 + z_1 \, z_4\right)^2}{\left(x_1^2 + y_1^2 + z_1^2\right) \, \left(x_4^2 + y_4^2 + z_4^2\right)}$$

In[21]:=
$$L_{12} = J[a_1, a_2]$$

$$L_{23} = J[a_2, a_3]$$

$$L_{34} = J[a_3, a_4]$$

$$L_{41} = J[a_4, a_1]$$

Out[21]=
$$\{-y_2 z_1 + y_1 z_2, x_2 z_1 - x_1 z_2, -x_2 y_1 + x_1 y_2\}$$

Out[22]=
$$\{-y_3 z_2 + y_2 z_3, x_3 z_2 - x_2 z_3, -x_3 y_2 + x_2 y_3\}$$

Out[23]=
$$\{-y_4 z_3 + y_3 z_4, x_4 z_3 - x_3 z_4, -x_4 y_3 + x_3 y_4\}$$

$$\text{Out} [\text{24}] = \; \left\{ \, y_4 \,\, z_1 \, - \, y_1 \,\, z_4 \, , \,\, - \, x_4 \,\, z_1 \, + \, x_1 \,\, z_4 \, , \,\, x_4 \,\, y_1 \, - \, x_1 \,\, y_4 \, \right\}$$

```
ln[25]:= S_1 = spread[L_{41}, L_{12}]
                                S_2 = spread[L_{12}, L_{23}]
                                S_3 = spread[L_{23}, L_{34}]
                                S_4 = spread[L_{34}, L_{41}]
Out[25]= 1 - ((-x_2 y_1 + x_1 y_2) (x_4 y_1 - x_1 y_4) + (x_2 z_1 - x_1 z_2) (-x_4 z_1 + x_1 z_4) + (-y_2 z_1 + y_1 z_2) (y_4 z_1 - y_1 z_4))^2 / (-x_4 z_1 + x_1 z_2) (y_4 z_1 - y_1 z_4)^2 / (-x_4 z_1 + x_1 z_2)^2 / (-x_4 z_1 + x_1 z_1 + x_1 z_2)^2 / (-x_4 z_1 + x_1 z_2)^2 / (-x_4 z_1 + x_1 z_1 + x_1 z_2)^2 / (-x_4 z_
                                              \left(\;\left(\;\left(\;-x_{2}\;y_{1}+x_{1}\;y_{2}\;\right)^{\;2}+\;\left(\;x_{2}\;z_{1}-x_{1}\;z_{2}\;\right)^{\;2}+\;\left(\;-y_{2}\;z_{1}+y_{1}\;z_{2}\;\right)^{\;2}\right)
                                                            ((x_4 y_1 - x_1 y_4)^2 + (-x_4 z_1 + x_1 z_4)^2 + (y_4 z_1 - y_1 z_4)^2))
\left(\;\left(\;\left(\;-\;x_{2}\;y_{1}\;+\;x_{1}\;y_{2}\;\right)\;^{2}\;+\;\left(\;x_{2}\;z_{1}\;-\;x_{1}\;z_{2}\;\right)\;^{2}\;+\;\left(\;-\;y_{2}\;z_{1}\;+\;y_{1}\;z_{2}\;\right)\;^{2}\;\right)
                                                            ((-x_3 y_2 + x_2 y_3)^2 + (x_3 z_2 - x_2 z_3)^2 + (-y_3 z_2 + y_2 z_3)^2)
((-x_3 y_2 + x_2 y_3)^2 + (x_3 z_2 - x_2 z_3)^2 + (-y_3 z_2 + y_2 z_3)^2)
                                                            ((-x_4 y_3 + x_3 y_4)^2 + (x_4 z_3 - x_3 z_4)^2 + (-y_4 z_3 + y_3 z_4)^2)
 \text{Out} [28] = \ 1 - \left( \ (x_4 \ y_1 - x_1 \ y_4) \ (-x_4 \ y_3 + x_3 \ y_4) \ + \ (-x_4 \ z_1 + x_1 \ z_4) \ (x_4 \ z_3 - x_3 \ z_4) \ + \ (y_4 \ z_1 - y_1 \ z_4) \ (-y_4 \ z_3 + y_3 \ z_4) \ \right)^2 \ / \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_3 + y_3 \ z_4) \ | \ (-y_4 \ z_4 + y_3 + y_3 \ z_4) \ | \ (-y_4 \ z_4 + y_4 + y_3 + y_3 \ z_4) \ | \ (-y_4 \ z_4 + y_4 
                                              \left(\;\left(\;\left(\;x_{4}\;y_{1}\;-\;x_{1}\;y_{4}\;\right)\;^{2}\;+\;\left(\;-\;x_{4}\;z_{1}\;+\;x_{1}\;z_{4}\;\right)\;^{2}\;+\;\left(\;y_{4}\;z_{1}\;-\;y_{1}\;z_{4}\;\right)\;^{2}\;\right)
                                                            ((-x_4 y_3 + x_3 y_4)^2 + (x_4 z_3 - x_3 z_4)^2 + (-y_4 z_3 + y_3 z_4)^2)
```

The next cell may take a long time to execute since the q's and the S's in the "res" equation are being substituted with the x's, y's and z's in the q's and S's expressions above and the whole thing is being factored. A result of zero indicates that the criteria for compatible equations in the quadratic compatibil ity theorem has been met.

```
In[29]:= result = Factor[res]
Out[29]= 0
```

We have proved that the two quadratic equations in B are compatible.