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2(a) $-\frac{1}{2}\left(\frac{1}{1}m_1\vartheta' + \dots\right)\left(\frac{1}{1}m_1\vartheta' + \dots\right)$

$= \boxed{-\frac{1}{2}m_1^2\vartheta^2}$

matched

$\frac{1}{2}k_2\vartheta^2 = \frac{1}{2}m_2\vartheta^2 - \frac{1}{2}m_1^2\vartheta^2$

$\Downarrow$

$\boxed{k_2 = m_2 - m_1^2}$

(iii) ϑ^3 coefficient

for $n=2$

$\boxed{\frac{1}{6}k_3\vartheta^3}$

for $n=1$, $k=3$

$\boxed{\frac{1}{6}m_3\vartheta^3}$

for $n=2$

$-\frac{1}{2}\left(\frac{1}{2}m_1m_2\vartheta^3 + \frac{1}{2}m_1m_2\vartheta^3\right)$

$= \boxed{-\frac{1}{2}m_1m_2\vartheta^3}$

for $n=3$

$\frac{1}{3}\left(m_1\vartheta + \dots\right)\left(m_1\vartheta + \dots\right)\left(m_1\vartheta + \dots\right)$

$= \boxed{\frac{1}{3}m_1^3\vartheta^3}$