v) Origin of S is at

$X' = \frac{x'_A(t) + x'_B(t)}{2}$ relative to S'

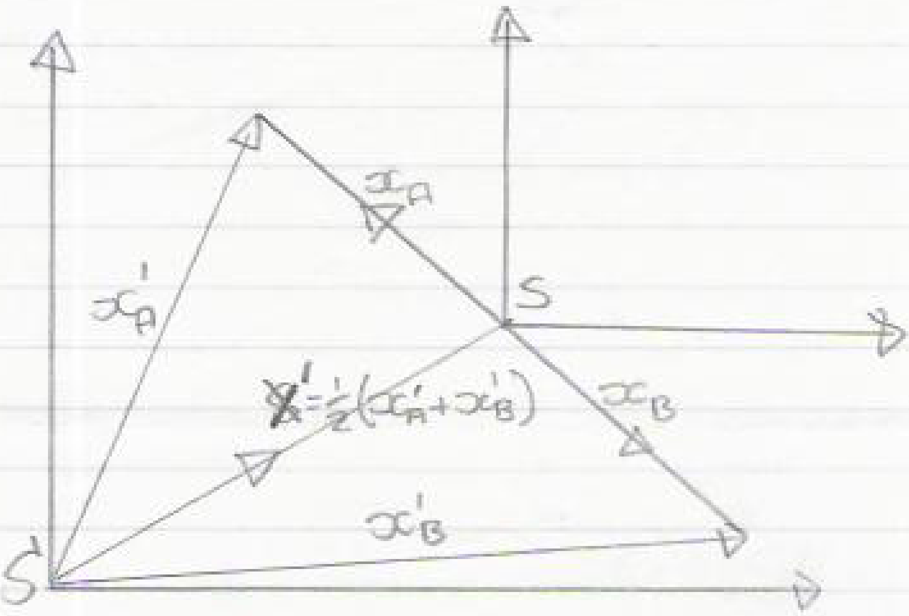
$= \frac{(2\cos 2t, \frac{1}{2}\sin 2t, t^2) + (0, -\frac{1}{2}\sin 2t, t^2)}{2}$

$= \frac{(2\cos 2t, 0, 2t^2)}{2} = (\cos 2t, 0, t^2)$

$X_A = x'_A - X$

$= (\cos 2t, \frac{1}{2}\sin 2t, 0)\,m$

$x_A =$



1 $x_A = -X' + x'_A$

$= -(\cos 2t, 0, t^2) + (2\cos 2t, \frac{1}{2}\sin 2t, t^2)$

1 $= (\cos 2t, \frac{1}{2}\sin 2t, 0)$

$x_B = -X' + x'_B$

1 $= -(\cos 2t, 0, t^2) + (0, -\frac{1}{2}\sin 2t, t^2)$

$= (-\cos 2t, -\frac{1}{2}\sin 2t, 0)$

$V_A = \frac{d(x_A)}{dt}$

$= \frac{d}{dt}(\cos 2t, \frac{1}{2}\sin 2t, 0)$

$= (-2\sin 2t, \cos 2t, 0)\ ms^{-1}$

$V_B = \frac{d(x_B)}{dt}$

$= \frac{d}{dt}(-\cos 2t, -\frac{1}{2}\sin 2t, 0)$

$= (2\sin 2t, -\cos 2t, 0)\ ms^{-1}$

$P = m_A v_A + m_B v_B$

2 $= \frac{1}{2}\frac{d}{dt}(\cos 2t, \frac{1}{2}\sin 2t, 0) + \frac{1}{2}\frac{d}{dt}(-\cos 2t, -\frac{1}{2}\sin 2t, 0)$

$= \frac{1}{2}(-2\sin 2t, \cos 2t, 0) + \frac{1}{2}(2\sin 2t, -\cos 2t, 0)$

$= (-\sin 2t + \sin 2t, \cos 2t - \cos 2t, 0 + 0) = (0, 0, 0)$ 7

2 Hence $P = (0, 0, 0)$

vi) $J = x_A \times (m_A v_A) + x_B \times (m_B v_B)$

$= (\cos 2t, \frac{1}{2}\sin 2t, 0) \times \left(\frac{1}{2}\frac{d}{dt}(\cos 2t, \frac{1}{2}\sin 2t, 0)\right)$