a) i) let $t=0$

$6 = Q_0 e^0$

$\therefore Q_0 = 6$

sub in $Q_0 = 6$ and $t = 15$ with $Q = 3$

$3 = 6e^{-15k}$

$\frac{1}{2} = e^{-15k}$

$\ln \frac{1}{2} = -15k$

$k = \frac{\ln \frac{1}{2}}{-15}$

ii) $\frac{1}{8} = 6e^{\frac{\ln \frac{1}{2} t}{15}}$

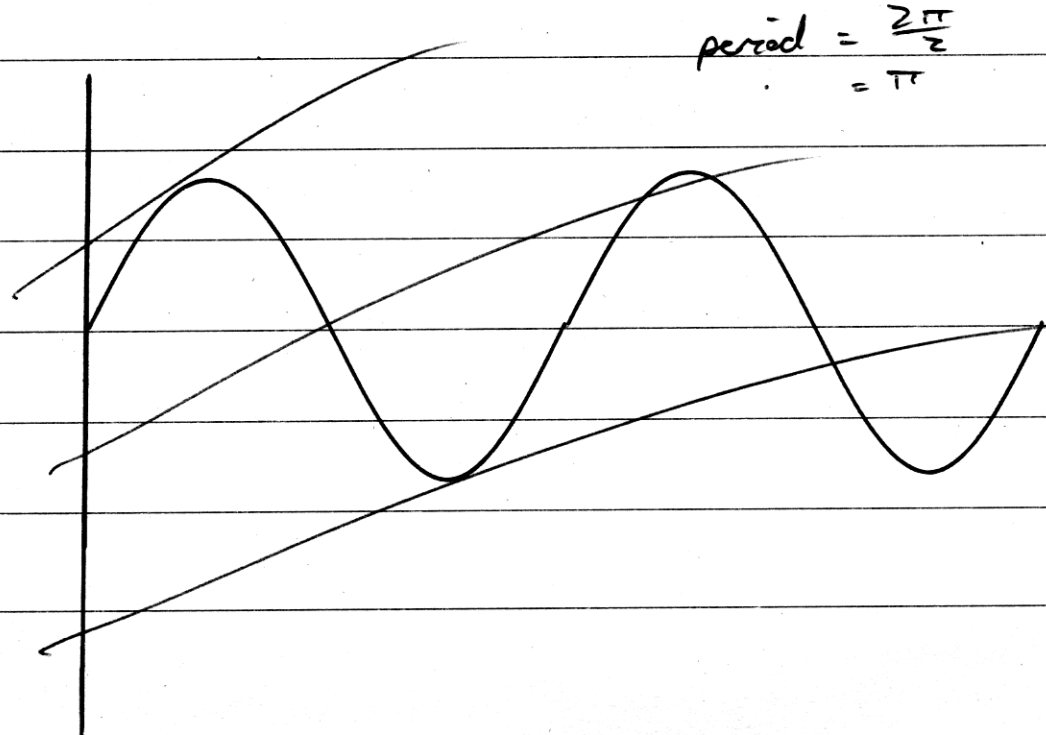
$\frac{1}{48} = e^{\frac{\ln \frac{1}{2} t}{15}}$

$\therefore \ln \frac{1}{48} = \frac{\ln \frac{1}{2} t}{15}$

$\therefore t = \frac{\ln \frac{1}{48}}{\ln \frac{1}{2}}$

$t = 83$ hrs 46 mins (nearest minute)

b) i)



period $= \frac{2\pi}{2}$

$= \pi$

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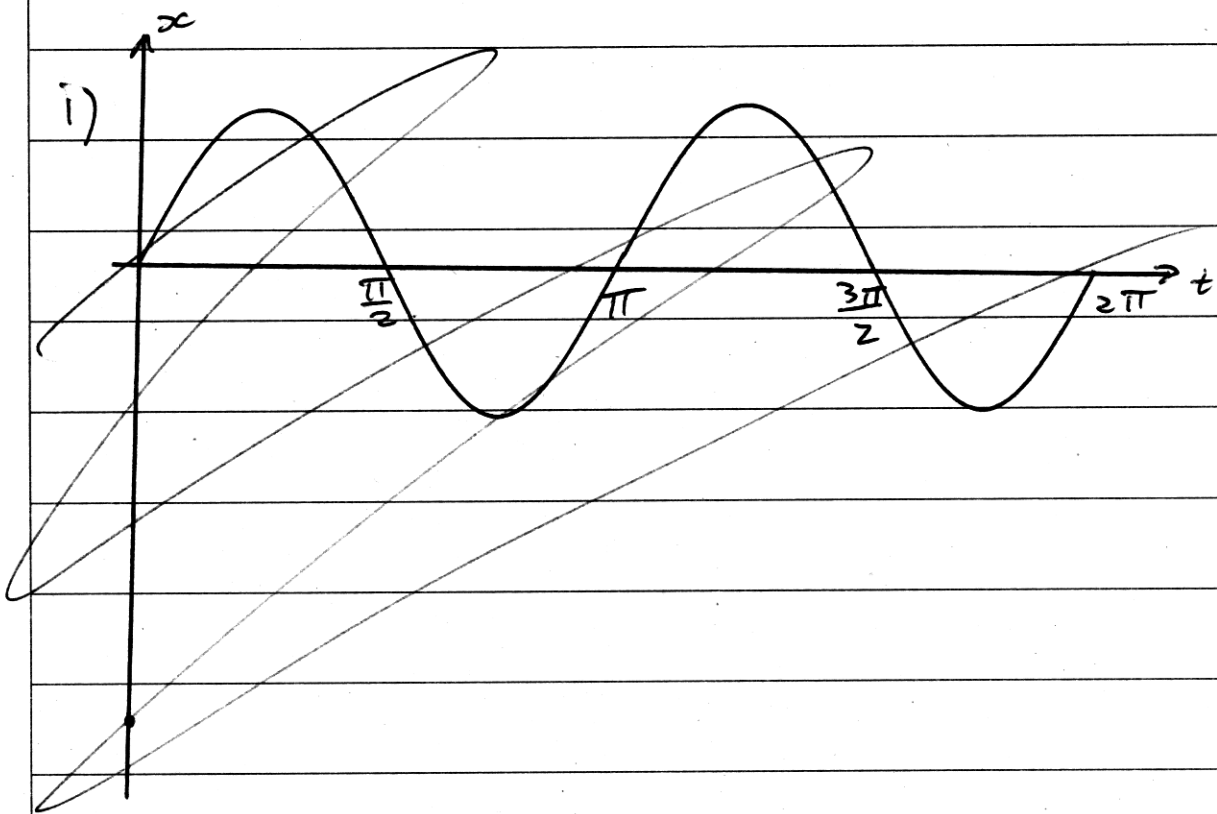
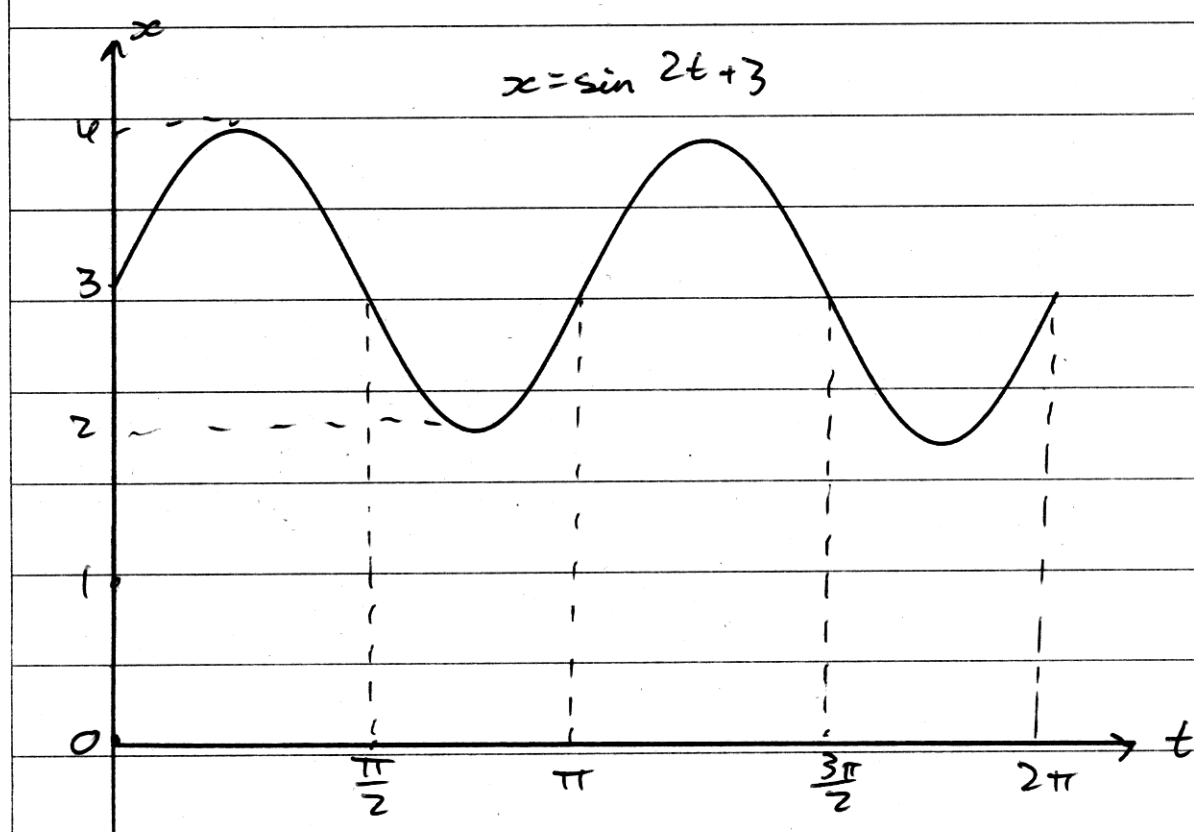
i)





by inspection the particle is at rest when $t = \frac{\pi}{4}, \frac{3\pi}{4}, \frac{5\pi}{4}, \frac{7\pi}{4}$

$x = 4m$ at $\frac{\pi}{4}$ sec $2m$ at $\frac{3\pi}{4}$ sec $4m$ at $\frac{5\pi}{4}$ sec and $2m$ at $\frac{7\pi}{4}$ sec

iii) the particle moves right, ~~from~~ starting 3 ~~units~~ metres right of the origin, slowing down until $\frac{\pi}{4}$ seconds ~~at~~ where it stops, turns left and accelerates until $\frac{\pi}{2}$ seconds where it ~~speeds~~ slows ~~up~~ and down and stops 2 metres right of the origin after $\frac{3\pi}{4}$ seconds. (the particle then completes another cycle the same as this until 2π seconds).

(~~it~~ turns right and accelerates until π seconds)