3(a)	$\frac{dv}{dt} = -\frac{1}{2}\left(v^2+4\right)$ $\frac{1}{2}\tan^{-1}\left(\frac{1}{2}v\right) = -\frac{1}{2}t\ [+A]$
	$t=0,\ v=2:\quad A = \frac{1}{2}\tan^{-1}\left(\frac{2}{2}\right) = \frac{1}{8}\pi$
	$v = \frac{dx}{dt} = 2\tan\left(\frac{1}{4}\pi - t\right)$ $x = 2\ln\left(\cos\left(t-\frac{1}{4}\pi\right)\right)[+B]$
	$x=0,\ t=0:\quad B=\ln 2$ $x = 2\ln\left(\cos\left(t-\frac{1}{4}\pi\right)\right)+\ln 2\ \left[=\ln\left(2\cos^2\left(t-\frac{1}{4}\pi\right)\right)\right]$
3(b)	$2\ln\left(\cos\left(t-\frac{1}{4}\pi\right)\right)+\ln 2 = 0$
	$t = \frac{1}{2}\pi$

7(a)	$-mgkv - \mu mg = m\frac{dv}{dt}$
	$t = -\frac{1}{g}\int \frac{1}{kv+\mu}dv$ $t = -\frac{1}{gk}\ln\left(kv+\mu\right)[+C]$
	When $v=u$, $t=0$: $\quad C = \frac{1}{gk}\ln\left(kU+\mu\right)$
	$t = -\frac{1}{gk}\ln\left(kv+\mu\right)+\frac{1}{gk}\ln\left(kU+\mu\right)$ $t = \frac{1}{gk}\ln\left(\frac{kU+\mu}{kv+\mu}\right)$

7(b)	$-\frac{2}{5}v-2=v\frac{\mathrm{d}v}{\mathrm{d}x}$ $x=-\frac{5}{2}\int\frac{v}{v+5}\mathrm{d}v=-\frac{5}{2}\int\left(1-\frac{5}{v+5}\right)\mathrm{d}v$
	$x=-\frac{5}{2}v+\frac{25}{2}\ln\left(v+5\right)\left[+C\right]$
	When $x=0,\ v=10:\ C=25-\frac{25}{2}\ln\left(15\right)$
	When $v=0,\ x=25-\frac{25}{2}\ln\left(15\right)+\frac{25}{2}\ln\left(5\right)=11.3$ [m]
	Alternative method for question 7(b)
	From part (a), $t=\frac{5}{2}\ln\left(\frac{15}{v+5}\right),\quad v=15\mathrm{e}^{-\frac{2}{5}t}-5$
	$x=-\frac{75}{2}\mathrm{e}^{-\frac{2}{5}t}-5t\left[+B\right]$
	When $t=0,\ x=0,\ B=\frac{75}{2},\qquad x=-\frac{75}{2}\mathrm{e}^{-\frac{2}{5}t}-5t+\frac{75}{2}$
	When $v=0,\ t=2.5\ln 3,\quad x=25-\frac{25}{2}\ln 3=11.3$ [m]

7(b)	**Alternative method for question 7(b)**
	From part (a), $t=\frac{5}{2}\ln\left(\frac{15}{v+5}\right),\quad v=15\mathrm{e}^{-\frac{2}{5}t}-5$
	When $v=0,\ t=2.5\ln 3$ so $x=\int_0^{2.5\ln 3}\left(15\mathrm{e}^{-\frac{2}{5}t}-5\right)\mathrm{d}t$
	$x=\left[-\frac{75}{2}\mathrm{e}^{-\frac{2}{5}t}-5t\right]_0^{2.5\ln 3}$
	$x=-\frac{75}{2}\times\frac{1}{3}-5\times 12.5\times\ln 3-\left(-\frac{75}{2}\right)=25-\frac{25}{2}\ln 3=11.3$ [m]
7(c)	Average speed $=\dfrac{\text{"11.3"}}{\frac{1}{10\times 0.04}\ln\left(\frac{0.04\times 10+0.2}{0.2}\right)}=\dfrac{\text{"11.3"}}{2.5\ln 3}$
	4.10 [$\mathrm{m\,s^{-1}}$]

5(a)	$mv\frac{\mathrm{d}v}{\mathrm{d}x} = -0.025v^2m - 10m$
	$\int \frac{v}{10+0.025v^2}\,\mathrm{d}v = -\int \mathrm{d}x$ $-0.025x[+c] = \frac{1}{2}\ln\left(v^2+400\right)$
	$c = \frac{1}{2}\ln 800$
	$v = 20\sqrt{2\mathrm{e}^{-\frac{1}{20}x} - 1}$
5(b)	$m\frac{\mathrm{d}v}{\mathrm{d}t} = -0.025v^2m - 10m$ $-\int \mathrm{d}t = \int \frac{1}{10+0.025v^2}\,\mathrm{d}v$ $-t[+k] = 2\tan^{-1}\frac{v}{20}$
	$k = 2\tan^{-1}\frac{20}{20} = \frac{1}{2}\pi$
	$v = 20\tan\left(\frac{1}{4}\pi - \frac{1}{2}t\right)$

1(a)	$x^3 + 4x = 8v\frac{\mathrm{d}v}{\mathrm{d}x}$
	$\int (x^3+4x)\,\mathrm{d}x = \int 8v\,\mathrm{d}v$ $4v^2 = \frac{1}{4}x^4 + 2x^2 + c$
	$v^2 = \frac{1}{16}x^4 + \frac{1}{2}x^2 + 1 \quad \left[= \left(\frac{1}{4}x^2+1\right)^2\right]$ $v = \frac{1}{4}x^2 + 1$
1(b)	$\frac{\mathrm{d}x}{\mathrm{d}t} = \frac{1}{4}x^2 + 1$ leading to $\int \frac{1}{\frac{1}{4}x^2+1}\,\mathrm{d}x = \int \mathrm{d}t$. $t = 4\int \frac{1}{x^2+4}\,\mathrm{d}x = 2\tan^{-1}\left(\frac{1}{2}x\right)[+C]$
	$C = 0$ so $x = 2\tan\left(\frac{1}{2}t\right)$

3(a)	$-mg - mkv^2 = mv\dfrac{\mathrm{d}v}{\mathrm{d}x}$
	$\int \mathrm{d}x = -\int \dfrac{v}{g+kv^2}\,\mathrm{d}v$ leading to $x = -\dfrac{1}{2k}\ln\left(g+kv^2\right)[+c]$.
	$v = U$ when $x = 0$, so $c = \dfrac{1}{2k}\ln\left(g+kU^2\right)$.
	$x = \dfrac{1}{2k}\ln\left(\dfrac{g+kU^2}{g+kv^2}\right)$ (metres)
3(b)	$10 + \frac{1}{40}v^2 = -\dfrac{\mathrm{d}v}{\mathrm{d}t}$ $\int \mathrm{d}t = -\int \dfrac{40}{400+v^2}\,\mathrm{d}v$
	$t = -\frac{40}{20}\tan^{-1}\left(\frac{1}{20}v\right)(+C)$
	When $t = 0, v = 20$, so $C = \frac{1}{2}\pi$ $t = -2\tan^{-1}(0) + \frac{1}{2}\pi$
	$t = 1.57$ (seconds)