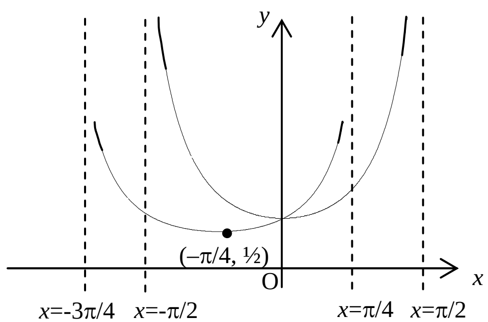
1			$h = r$ so $V = \pi h^3/3$	B1	o.e. e.g $\pi h^3 \tan 45°/3$	
			$dV/dt = 5$	B1	soi (can be implied from $V = 5t$)	e.g. from a correct chain rule
			$dV/dh = \pi h^2$	B1ft	must be dV/dh soi, ft their $\pi h^3/3$	but must have substituted for r
			$dV/dt = (dV/dh).\ dh/dt$	M1	any correct chain rule in V, h and t (soi)	e.g. $dh/dt = dh/dV \times dV/dt$,
			$\Rightarrow \quad 5 = 100\pi\ dh/dt$			
			$\Rightarrow \quad dh/dt = 5/100\pi = 0.016$ cm s^{-1}	A1	0.016 or better; accept $1/(20\pi)$ o.e., but mark final answer	0.01591549… penalise incorrect rounding
			or $V = 5t$ so $\pi h^3/3 = 5t$	B1		
			$\Rightarrow \pi h^2 dh/dt = 5$	M1	or $5\ dt/dh = \pi h^2$ o.e.	
			$\Rightarrow dh/dt = 5/\pi h^2 = 5/100\pi = 0.016$ cm s^{-1}	A1	0.016 or better; accept $1/(20\pi)$ o.e., but mark final answer	penalise incorrect rounding
				[5]		

2			$dV/dr = 4\pi r^2$	B1	or $12\pi r^2/3$, condone dr/dV, dV/dR	
			$dV/dt = 10$	B1		Condone use of other letters for t
			$dV/dt = (dV/dr)(dr/dt)$	M1	a correct chain rule soi	o.e. e.g. $dr/dt = (dr/dV)(dV/dt)$
			$\Rightarrow \quad 10 = 4\pi.64.dr/dt$	A1	o.e. (soi) must be correct	
			$\Rightarrow \quad dr/dt = 0.0124$ cm s^{-1}	A1	0.012 or better or $10/256\pi$ or $5/128\pi$	mark final answer
				[5]		

3	**(i)**		$dF/dv = -25\,v^{-2}$	M1 A1 **[2]**	$d/dv(v^{-1}) = -v^{-2}$ soi $-25\,v^{-2}$ o.e mark final ans	
	(ii)		When $v = 50$, $dF/dv = -25/50^2$ (= –0.01) $\frac{dF}{dt} = \frac{dF}{dv}.\frac{dv}{dt}$ = –0.01 × 1.5 = –0.015	B1 M1 A1cao **[3]**	$-25/50^2$ o. o.e. e.g. −3/200 isw	e.g. $\frac{dF}{dv} = \frac{dF}{dt} / \frac{dv}{dt}$

4			$V = \pi h^2 \Rightarrow dV/dh = 2\pi h \Rightarrow$ $dV/dt = dV/dh \times dh/dt$ $dV/dt = 10$ $dh/dt = 10/(2\pi \times 5) = 1/\pi$	M1A1 M1 B1 A1 **[5]**	if derivative $2\pi h$ seen without $dV/dh = \ldots$ allow M1A0 soi ; o.e. – any correct statement of the chain rule using V, h and t – condone use of a letter other than t for time here soi; if a letter other than t used (and not defined) B0 or 0.32 or better, mark final answer

5(i) $\frac{d}{dx}\left(\frac{\sin x}{\cos x}\right) = \frac{\cos x.\cos x - \sin x.(-\sin x)}{\cos^2 x}$ $= \frac{\cos^2 x + \sin^2 x}{\cos^2 x} = \frac{1}{\cos^2 x}$ *	M1 A1 A1 [3]	Quotient (or product) rule (**AG**)	product rule: $\frac{1}{\cos x}.\cos x + \sin x(-\frac{1}{\cos^2 x})(-\sin x)$ but must show evidence of using chain rule on 1/cos x (or d/dx (sec x) = sec x tan x used)
(ii) Area = $\int_0^{\pi/4} \frac{1}{\cos^2 x} \, dx$ $= [\tan x]_0^{\pi/4}$ = tan(π/4) – tan 0 = 1	B1 M1 A1 [3]	correct integral and limits (soi) $[\tan x]$ or $\left[\frac{\sin x}{\cos x}\right]$	condone no dx; limits can be implied from subsequent work unsupported scores M0
(iii) f(0) = 1/cos^2(0) = 1 g(x) = 1/2cos^2(x + π/4) g(0) = 1/2cos^2(π/4) = 1 (⇒ f and g meet at (0, 1))	B1 M1 A1 [3]	must show evidence	 or f(π/4) = 1/cos^2(π/4) = 2 so g(0) = ½ f(π/4) = 1
(iv) Translation in x-direction through –π/4 Stretch in y-direction scale factor ½ 	M1 A1 M1 A1 B1ft B1ft B1 B1dep [8]	must be in x-direction, or $\begin{pmatrix} -\pi/4 \\ 0 \end{pmatrix}$ must be in y-direction asymptotes correct min point (–π/4, ½) curves intersect on y-axis correct curve, dep B3, with asymptote lines indicated and correct, and TP in correct position	'shift' or 'move' for 'translation' M1 A0; $\begin{pmatrix} -\pi/4 \\ 0 \end{pmatrix}$ alone SC1 'contract' or 'compress' or 'squeeze' for 'stretch' M1A0; 'enlarge' M0 stated or on graph; condone no x = …, ft π/4 to right only (viz. –π/4, 3π/4) stated or on graph; ft π/4 to right only (viz. (π/4, ½)) 'y-values halved', or 'x-values reduced by π/4, are M0 (not geometric transformations), but for M1 condone mention of x- and y- values provided transformation words are used.
(v) Same as area in (ii), but stretched by s.f. ½ . So area = ½ .	B1ft [1]	½ area in (ii)	or $\int_{-\pi/4}^{0} g(x)\,dx = \frac{1}{2}\int_{-\pi/4}^{0} \frac{1}{\cos^2(x+\pi/4)}\,dx = \frac{1}{2}[\tan(x+\pi/4)]_{-\pi/4}^{0}$ = ½ allow unsupported

6 (i) 5 = k/100 ⇒ k = 500*	E1 [1]	NB answer given
(ii) $\frac{dP}{dV} = -500V^{-2} = -\frac{500}{V^2}$	M1 A1 [2]	$(-1)V^{-2}$ o.e. – allow $-k/V^2$
(iii) $\frac{dP}{dt} = \frac{dP}{dV}.\frac{dV}{dt}$ When V = 100, dP/dV = –500/10000 = –0.05 dV/dt = 10 ⇒ dP/dt = –0.05 × 10 = –0.5 So P is decreasing at 0.5 Atm/s	M1 B1ft B1 A1 [4]	chain rule (any correct version) (soi) (soi) –0.5 ca

7 (i) $\frac{dV}{dt} = 2$ **(ii)** tan 30 = 1/√3 = r/h ⇒ $h = \sqrt{3}\, r$ ⇒ $V = \frac{1}{3}\pi r^2.\sqrt{3}r = \frac{\sqrt{3}}{3}\pi r^3$* $\frac{dV}{dr} = \sqrt{3}\pi r^2$ **(iii)** When r = 2 , dV/dr = 4√3π $\frac{dV}{dt} = \frac{dV}{dr}.\frac{dr}{dt}$ ⇒ 2 = 4√3π dr/dt ⇒ dr/dt = 1/(2√3π) or 0.092 cm s^{-1}	B1 M1 E1 B1 M1 M1 A1cao [7]	 Correct relationship between r and h in any form From exact working only o.e. e.g. (3√3/3)π r^2 or $\frac{dr}{dt} = \frac{dr}{dV}.\frac{dV}{dt}$ substituting 2 for dV/dt and r = 2 into their dV/dr

8(i) $V = \pi h^2 - \frac{1}{3}\pi h^3$ $\Rightarrow \frac{dV}{dh} = 2\pi h - \pi h^2$ **(ii)** $\frac{dV}{dt} = 0.02$ $\frac{dV}{dt} = \frac{dV}{dh}.\frac{dh}{dt}$ $\Rightarrow \frac{dh}{dt} = \frac{0.02}{dV/dh} = \frac{0.02}{2\pi h - \pi h^2}$ When h = 0.4 , $\Rightarrow \frac{dh}{dt} = \frac{0.02}{0.8\pi - 0.16\pi} = 0.0099\,\text{m/min}$	M1 A1 B1 M1 M1dep A1cao [6]	expanding brackets (correctly) or product rule oe soi $\frac{dV}{dt} = \frac{dV}{dh}.\frac{dh}{dt}$ oe substituting h = 0.4 into their $\frac{dV}{dh}$ and $\frac{dV}{dt} = 0.02$ 0.01 or better or 1/32π