# SOLUTIONS C106 THERMODYNAMIC, FLUID AND PROCESS ENGINEERING <br> Year 2004 

Q7 A jet of water flows smoothly onto a stationary curved vane which turns it through an angle of $50^{\circ}$ as shown. The jet flows onto the vane with a velocity of $40 \mathrm{~m} / \mathrm{s}$ and a circular cross section of diameter 0.04 m . The water leaves the vane with a velocity of $36 \mathrm{~m} / \mathrm{s}$. Calculate the magnitude and direction of the force on the vane. Neglect gravitational effects.


The vector diagram is constructed as shown. Find the change in velocity $\Delta v$
$\mathrm{C}=36 \sin 50=27.577 \quad \mathrm{~A}=36 \cos 50=23.14$
$\mathrm{B}=40-\mathrm{A}=16.86 \quad \Delta \mathrm{~V}=\sqrt{ }\left(27.577^{2}+16.86^{2}\right)=32.32 \mathrm{~m} / \mathrm{s}$
Mass flow $=\rho \mathrm{Av}=1000 \times \pi \times 0.04^{2} / 4 \times 40=50.265 \mathrm{~kg} / \mathrm{s}$
$\mathrm{F}=\mathrm{m} \Delta \mathrm{v}=1625 \mathrm{~N}$
$\theta=\tan ^{-1}(27.577 / 16.86)=58.6^{\circ}$
The force on the vane is the opposite direction to $\Delta \mathrm{V}$

