Oblique Shock Waves
Fundamentals

• Shock doesn’t change velocity component tangent to it, so $u_{t1}=u_{t2}=u_t$

• Observer traveling along shock at $u_t$ sees a normal shock with upstream Mach no. $M_{1n}$

• Oblique shock can thus be analyzed as a normal shock with $M_1$ and $M_2$ replaced by $M_{1n}$ and $M_{2n}$

\[ u_{1n} = u_1 \sin \beta \quad M_{1n} = M_1 \sin \beta \quad u_{1t} = u_1 \cos \beta \]

\[ u_{2n} = u_2 \sin(\beta - \delta) \quad M_{2n} = M_2 \sin(\beta - \delta) \quad u_{2t} = u_2 \cos(\beta - \delta) \]
The $M-\beta-\delta$ Relationship

For a Normal Shock

$$\frac{u_2}{u_1} = \frac{(\gamma - 1)M_1^2 + 2}{(\gamma - 1)M_1^2}$$

$$u_{1n} = u_1 \sin \beta$$
$$u_{2n} = u_2 \sin(\beta - \delta)$$
$$M_{1n} = M_1 \sin \beta$$
$$M_{2n} = M_2 \sin(\beta - \delta)$$
$$u_{1t} = u_1 \cos \beta$$
$$u_{2t} = u_2 \cos(\beta - \delta)$$
Strong shocks

Weak shocks

Deflection angle $\delta$

Shock Wave Angle $\beta$

TABLES
Example

Find $M_2$, $p_2$, $T_2$ and $p_{01}/p_{02}$

$M_1 = 1.7$
$p_1 = 50\text{kPa}$
$T_1 = 200\text{K}$

12°
Variations
Find $M_2$, $p_2$, $T_2$ and $p_{01}/p_{02}$

Suppose...
• it was a wedge?

or a plate?

or followed by an expansion?
Variations

Find $M_2, p_2, T_2$ and $p_{01}/p_{02}$

Suppose...

• $p_2/p_1$ given instead of $\delta$?
Shock Detachment

Suppose the turn angle in our example had been 20°?
Air flow over a cone at Mach 3, as a function of cone half angle