

Advanced physics exam

1a) ~~1a)~~ $\frac{d}{dt} \left(\frac{p_x}{E} \right) + \frac{d}{dx} \left(\frac{p_x u_x}{H + u_x^2} + p \right) = 0$

p_2	p_1
p_1	p_1
u_2	u_1
H_2	H_1

$p_1 u_1 = p_2 u_2$

b) $D = a + bu$

$a = 1.45 \text{ km s}^{-1}$

$b = 1.99$

$u = 0.5 \text{ km s}^{-1}$

$D = 1.45 + 1.99 \times 0.5 = 2.445$

$\rho = 1000 \text{ kg m}^{-3}$

$p_1 = 0$

$u = 0$

~~$p_1 u_1 + p_1 = p_2 u_2 + p_2$~~ $(p_1 - p_2) = \rho D u_1$

$(p_2 - 0) = 1000 \times 2.445 \times 0.5$

$(p_2 - 0) = 12225$

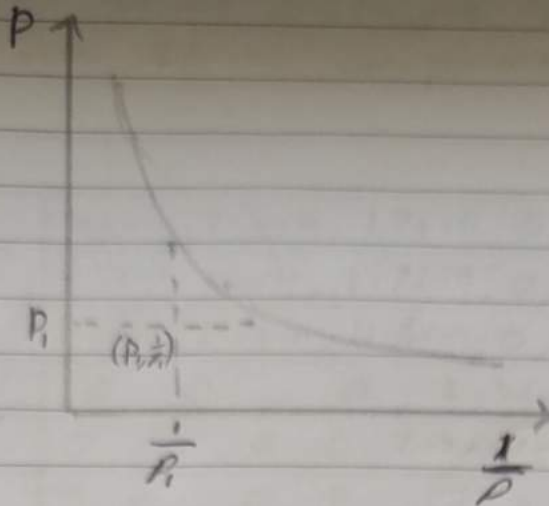
$p_2 = 12225 \text{ Pa}$

$p_1 D = p_2 (D - u_2)$

$1000 \times 2.445 = p_2 (2.445 - 0.5)$

$2445 = 1.945 p_2$ $p_2 = \frac{2445}{1.945} = 1257.07 \text{ kg m}^{-3}$

1c)

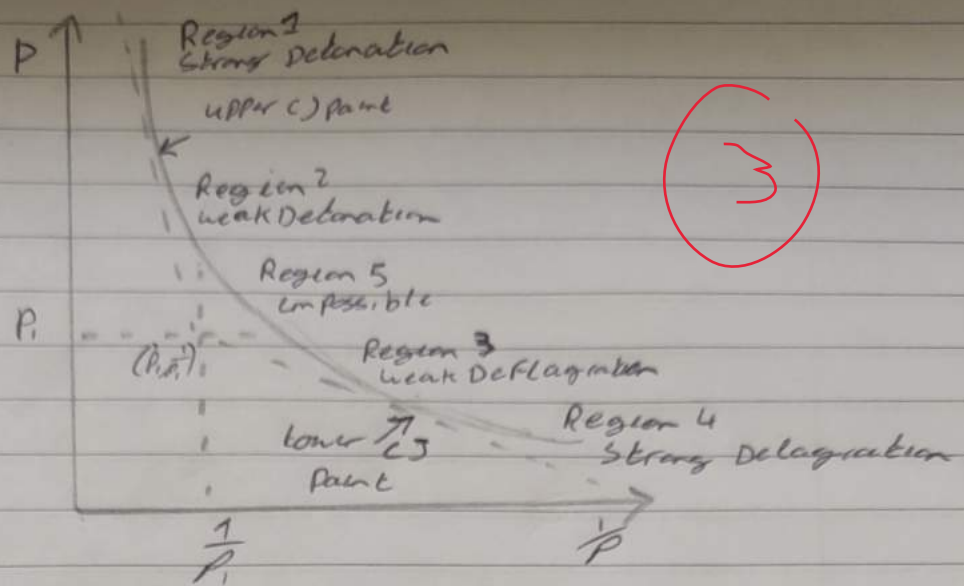


When the fluid is subjected to a shock wave the pressure is increased causing a lower specific density. This compression also causes heating of the fluid.

(C)

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1d)



A deflagration ^{characterized} is a subsonic flame propagation velocity and relatively modest over pressures. The reaction zone progresses through the medium by processes of diffusion of heat and mass.

A detonation is characterized by a supersonic flame propagation velocity and substantial over pressure. The detonation propagation is a pressure wave that compresses the unburnt gas ahead of the wave to a temperature above autoignition. Because of this it is easier to have a detonation in a high pressure environment.

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2a) each stress component is a linear combination of all stress components.

Strain

b) i)

$$\begin{bmatrix} 4e+11 & 1.7e+11 & 1.7e+11 & 0 & 0 & 0 \\ 1.7e+11 & 4e+11 & 1.7e+11 & 0 & 0 & 0 \\ 1.7e+11 & 1.7e+11 & 4.6e+11 & 0 & 0 & 0 \\ 0 & 0 & 0 & 2.3e+11 & 0 & 0 \\ 0 & 0 & 0 & 0 & 2.3e+11 & 0 \\ 0 & 0 & 0 & 0 & 0 & 2.3e+11 \end{bmatrix}$$

ii) $(4e+11 \times 0.05) + (1.7e+11 \times 0.1) + (1.7e+11 \times 0.05)$

$$\sigma_{xx} = 4.6e+10$$

ci) The deviatoric stress matrix is found by subtracting the hydrostatic stress value from each diagonal term in the stress matrix.

ii) deviatoric matrix shows the stress response for plastic deformation.

$$\frac{8}{15}$$

3a) $PV = nRT$

~~$n = \frac{PV}{RT}$~~ $n = \frac{PV}{RT}$

$$n = \frac{2.5 \times 10^6 \times 0.4}{8.31 \times 313.15}$$

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$n = 384.28 \text{ moles (2d.p)}$

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3bi) $P_1 V_1 = P_2 V_2$

$$P_2 = \frac{P_1 V_1}{V_2}$$

$$P_2 = \frac{5 \times 10^6 \times 0.2}{0.15} = \underline{\underline{6.67 \times 10^6 \text{ (2d.p)}}}$$

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ii) $\gamma = \frac{C_p}{C_v} \quad \gamma = \frac{919.8}{657} = 1.4$

$$P_3 V_1^\gamma = P_2 V_2^\gamma$$

$$P_3/P_2 = (V_2/V_1)^\gamma$$

$$\log\left(\frac{P_3}{P_2}\right) = \gamma \log\left(\frac{V_2}{V_1}\right)$$

$$P_3 = P_2 \exp\left(\gamma \log\left(\frac{V_2}{V_1}\right)\right)$$

$$P_3 = 6.67 \times 10^6 \exp\left(1.4 \log\left(\frac{0.15}{0.2}\right)\right) = \underline{\underline{4.46 \times 10^6 \text{ (2d.p)}}}$$

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Q3biii)

$$Pv = nRT$$

$$P_2 V_2 = nRT_1 \quad nR = \frac{P_2 V_2}{T_1}$$

$$P_3 V_1 = nRT_2 \quad nR = \frac{P_3 V_1}{T_2}$$

$$\frac{P_2 V_2}{T_1} = \frac{P_3 V_1}{T_2}$$

$$T_2 P_2 V_2 = T_1 P_3 V_1$$

$$T_2 = \frac{T_1 P_3 V_1}{P_2 V_2}$$

$$T_2 = \frac{300 \times 4.46e^{+6} \times 0.2}{6.67e^{+6} \times 0.15} = \underline{267.47 \text{ Kelvin}}$$

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5.

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- 4a) du = increase in internal energy of system
 dw = work done by system
 dQ = Heat energy supplied to system

b) $dQ = mc dT + dw$

$$0 = 0.01 \times 500 \times dT + 250$$

~~$dT = 250$~~

$$\Delta T = \frac{250}{0.01 \times 500} = \underline{\underline{50K}}$$

c) $15 = du + 7$

$$du = 15 - 7 = \underline{\underline{8J}}$$

d) ~~$\int_{293.15}^{353.15} \frac{dQ}{T} = \int_{293.15}^{353.15} \frac{mc dt}{T}$~~

$$ds = \int_{293.15}^{353.15} \frac{dQ}{T} = \int_{293.15}^{353.15} \frac{mc}{T} dt$$

$$= mc \log \left(\frac{353.15}{293.15} \right) = 7 \times 4.2 \times 10^3 \times \log \left(\frac{353.15}{293.15} \right)$$

$$ds = 5.47 \text{ KJ K}^{-1}$$