Tentative solution Geofysics Exam 2017

Problem 1

a) $f_N = \frac{1}{2\times10^{-3}} = \frac{1000}{2} = 500\ \text{Hz}$

Alternative **4**.

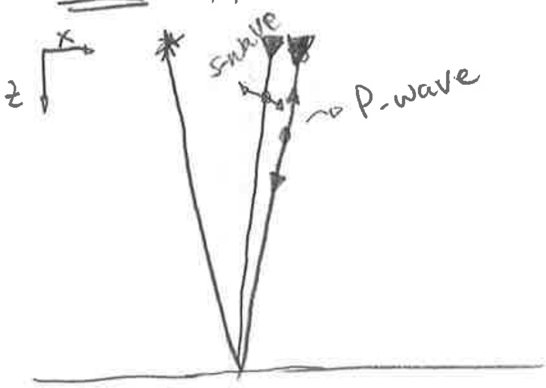
b) P-waves are longitudinal waves, whose polarization is in the direction of wave propagation.

S-waves are transverse waves. Their polarization is perpendicular to wave propagation.

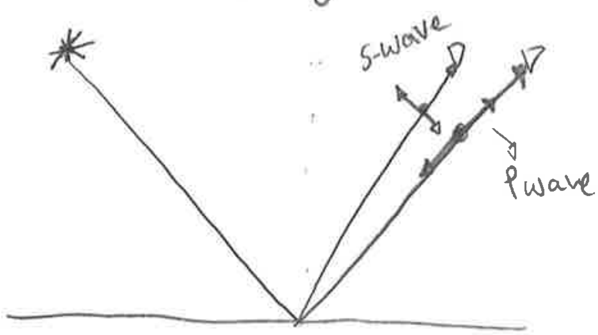
P-waves travel faster than S-waves.

S-waves cannot travel in fluids.

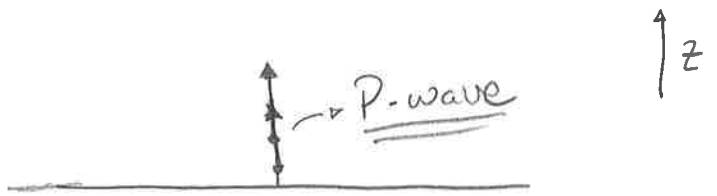
Good approximation for narrow angles



Poor approximation for wide angles



c) This is a plane wave propagating in the z - direction with motion in the z-direction.



alternative 3

d) Limit of resolution $z = \lambda/2$

$\lambda = \frac{v}{f}$

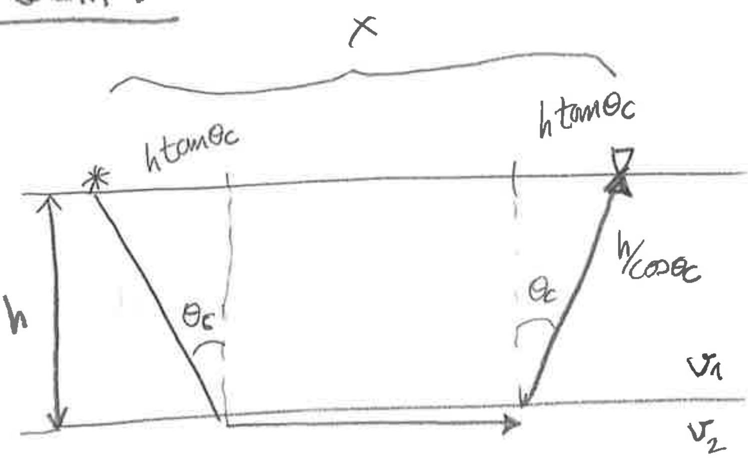
1000 m

$v = 2300.0$ m/s $f = 45$ Hz $z = \frac{2300.0}{90.0} = 25.5$ m

4000 m

$v = 3000.0$ m/s $f = 12.5$ Hz $z = \frac{3000.0}{25} = 120$ m

Problem 2



i) • $V_2 > V_1$.

• Long enough offset .

ii) $\frac{\sin\theta_c}{v_1} = \frac{\sin 90°}{v_2}$ $\sin\theta_c = \frac{v_1}{v_2}$

iii) $t = \frac{x - 2h\tan\theta_c}{v_2} + \frac{2.h}{v_1 . \cos\theta_c}$

$t = \frac{x}{v_2} + \frac{2h}{v_1 v_2 \cos\theta_c} . (v_2 - v_1 \cos\theta_c . \tan\theta_c)$ ← $\tan\theta_c = \frac{\sin\theta_c}{\cos\theta_c}$, $\sin\theta_c = \frac{v_1}{v_2}$

$t = \frac{x}{v_2} + \frac{2h}{v_1 v_2 \cos\theta_c} . \left(v_2 - \frac{v_1^2}{v_2}\right)$

$\cos^2\theta_c = 1 - \sin^2\theta_c = 1 - \frac{v_1^2}{v_2^2} = \frac{v_2^2 - v_1^2}{v_2^2}$

$t = \frac{x}{v_2} + \frac{2h}{v_1 \cos\theta_c} (\cos^2\theta_c)$

$\cos\theta_c = \frac{\sqrt{v_2^2 - v_1^2}}{v_2}$

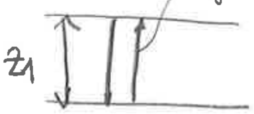
$$\boxed{t = \frac{x}{v_2} + \frac{2h}{v_1 v_2} . \sqrt{v_2^2 - v_1^2}}$$

b) i) $t_1^2(x) = t_{0,1}^2 + \frac{X^2}{V_1^2}$ $\qquad V_{RMS,1} = V_1$

$$V_1^2 = \frac{X^2}{t_1(x)^2 - t_{0,1}^2} \qquad V_1 = \sqrt{\frac{X^2}{t_1^2(x) - t_{0,1}^2}}$$

Choosing $X = 400$ m and using traveltimes for ref 1.

$$V_1 = \sqrt{\frac{400^2}{t(400)^2 - t_{0,1}^2}} \simeq 1900 \text{ m/s}$$



$$t_0 = \frac{2 z_1}{V_1}$$

$$z_1 = \frac{V_1 \cdot t_{0,1}}{2} = \frac{1900 \cdot 263{,}1 \times 10^{-3}}{2}$$

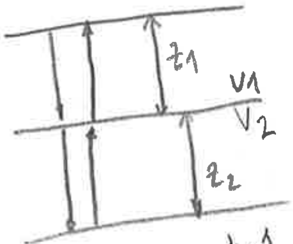
$$z_1 = 250 \text{ m}$$

ii) $t_2^2 = t_0^2 + \frac{X^2}{V_{RMS_2}^2}$

$$V_{RMS_2}^2 = \frac{X^2}{t_2^2(x) - t_{0,2}^2}$$

$$V_{RMS_2} = \sqrt{\frac{400^2}{t_2^2(400) - t_{0,2}^2}} \simeq 2109 \text{ m/s}$$

iii) Using Dix formula $\quad V_2 = \sqrt{\frac{V_{RMS_2}^2 \cdot t_{0,2} - V_{RMS_1}^2 \cdot t_{0,1}}{t_{0,2} - t_{0,1}}}$



$$V_2 \simeq 2400 \text{ m/s}$$

$$t_{0,2} = \underbrace{\frac{2 z_1}{V_1}}_{= t_{0,1}} + \frac{2 z_2}{V_2} \qquad z_2 = \frac{(t_{0,2} - t_{0,1}) \cdot V_2}{2} \simeq 200 \text{ m}$$

Problem 2 c)

i) Figure 2 shows the process of velocity analysis

ii) Left: Semblance, Middle: CMP gather.
"Common midpoint gather" (CMP)

iii) White curve: RMS velocity curve

Black curve: Interval velocity curve.

iv) NMO correction

v) Stack is the result of summing together all the traces in the CMP gather. It is a trace having the traveltime of the zero offset trace and an averaged amplitude over the range of angles of reflection.

Problem 2d)

$Z_0 = 1.2 \times 300$

$Z_1 = 1040 \times 1500$

$Z_2 = 1400 \times 1800$

$Z_3 = 2100 \times 2500$

$$R_{10} = \frac{Z_0 - Z_1}{Z_0 + Z_1} = -0.9995$$

⋮

$$R_{12} = \frac{Z_2 - Z_1}{Z_2 + Z_1} = 0.2353$$

$$T_{12} = 1 - R_{12}$$

2d) cont

$A_1 = A_0 . T_{1,2} \times R_{2,3} \times T_{2,1} = 0.3319 . A_0$

$T_{1,2} = 0.7647$

$R_{2,3} = 0.3514$

$T_{2,1} = 1.2353$

$A_2 = A_0 \times T_{1,2} \times R_{2,3} \times T_{2,1} \times R_{1,0} \times R_{1,2} =$

$= A_0 \times 0.3319 \times -1 \times 0.2353 = -0.0781 . A_0$

Problem 3

a) $g\varphi$ → gravity as a function of latitude

φ → Latitude

Equator:

$\varphi = 0°$ $g\varphi = 9.780327 \ m/s^2$

Poles

$\varphi = \pm 90°$ $g\varphi \cong 9.8322 \ m/s^2$

b) • Latitude correction

- Elevation correction (Free air correction)
- Extra mass correction (Bougher correction)

c) i) Geology varies mostly in the vertical direction

ii) Geology varies mostly in the horizontal direction.

iii) Geology varies both vertically and horizontally.

Problem 3:

d) $R_A = r_B = 2a$ $\quad$ $r_A = R_B = a$

$$\rho_a = \frac{2\pi (V_C - V_D)}{I} \cdot \frac{1}{\frac{1}{a} - \frac{1}{2a} - \frac{1}{2a} + \frac{1}{a}} = \frac{2\pi(V_C - V_D)}{I \cdot \frac{1}{a}} =$$

$$= \frac{2\pi (V_C - V_D)}{I} \cdot a \quad //$$