Problem Set 1 Solutions

Problem 1

$$\Delta P \approx \frac{\rho U^2}{2A^2} \qquad (1)$$

(a) From the information given, we know that

$\Delta P = 7$ cm $H_2O = 7 \times 980$ dyne/cm^2 = 6860 dyne/cm^2
$U_{max} = 600$ cm^3/sec
$\rho = 0.00114$ gm/cm^3
$A_{max} = l \times w$
$l = 1.0$ cm
w = (unknown) glottal width

we first calculate A_{max} by plugging in all the known numbers into equation(1),

$$A_{max} = \sqrt{\frac{\rho U^2}{2 \cdot \Delta P}} = 0.173\,\text{cm}^2$$

we then calculate the glottal width, knowing what A_{max} is and get

maximum glottal width = w = 0.173 cm

(b)

$$\Delta P = \frac{\rho U^2}{2A^2} + \frac{12\mu U d}{ba^3} \qquad (2)$$

$\mu = 1.94 \times 10^{-4}$ dyne-sec/cm^2
a = width of glottis = 0.173 cm (from part a)
b = horizontal length of glottis = 1.0 cm
d = vertical length of glottis = 0.3 cm
A = ab

Plugging all the values into the second term of equation(2), we get

ΔP (second term) = 80.931 dyne/cm^2
This viscosity term accounts for $\frac{80.931}{6860} \cdot 100\% = 1.18\%$ of the entire ΔP, which is not significant here.

Problem 2

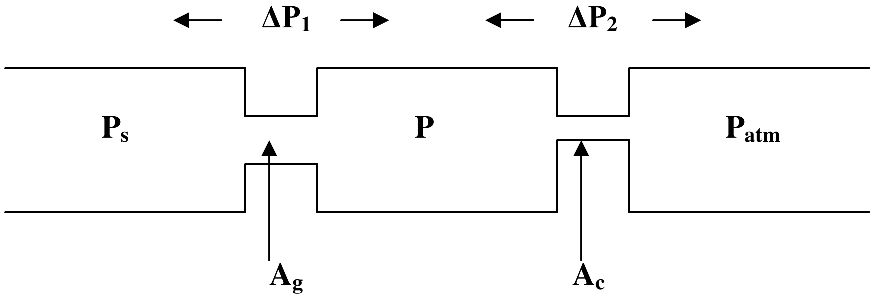

Figure 1

$$\Delta P \approx \frac{\rho U^2}{2A^2} \tag{3}$$

(a)

First, remember all pressures are given relative to the atmospheric pressure. From the problem, we know that

P_s = subglottal pressure = 6 cm H_2O = 6 x 980 dynes/cm^2 = 5880 dynes/cm^2
A_g = glottal constriction area = 0.2 cm^2
A_c = constriction area at palate = 0.1 cm^2
ρ = 0.00114 gm/cm^3

From Figure 1, we see that

ΔP_1 = pressure drop across the glottis = $P_s - P$
ΔP_2 = pressure drop across the constriction at palate = $P - P_{atm}$

=> $\Delta P_1 + \Delta P_2 = P_s - P + P - P_{atm} = P_s - P_{atm}$ = 5880 dyne/cm^2

Using equation(3), we can calculate U since all the other variables are known:

$$\Delta P_1 + \Delta P_2 = \frac{\rho U^2}{2A_g^2} + \frac{\rho U^2}{2A_c^2} = 6 \text{ cm } H_2O = 5880 \text{ dyne/cm}^2 \tag{4}$$

$$U = \sqrt{\left[\frac{1}{A_g^2} + \frac{1}{A_c^2}\right]^{-1} \cdot \frac{5880 \cdot 2}{\rho}}$$

$\boxed{U = 287.274 \text{ cm}^3/\text{s}}$

(b)

From Figure 1, we see that

$P = P_s - \Delta P_1$

$= P_s - \dfrac{\rho U^2}{2A_g^{\ 2}}$ (U is calculated in part (a), and the rest are given information)

$= 5880 \text{ dynes/cm}^2 - 1176 \text{ dynes/cm}^2$

$\boxed{P = 4703 \text{ dynes/cm}^2 = 4.799 \text{ cm } H_2O}$

(c)

Method 1:

The threshold pressure drop across the glottis for vibration to occur is $\Delta P_1 = 3$ cm H_2O.

Using equation(4) again, we get $\Delta P_2 = 3$ cm H_2O.

We can then calculate the new volume velocity U_{new} by using the relation

$$\Delta P_2 = \frac{\rho U_{new}^{\ 2}}{2A_c^{\ 2}} = 3 \text{ cm } H_2O$$

$$\Rightarrow U_{new} = 227.11 \text{ cm}^3/\text{s}$$

Since the volume velocity is equal at the two constrictions, we obtain the final answer A_g by using the same relation,

$$\Delta P_1 = \frac{\rho U_{new}^{\ 2}}{2A_g^{\ 2}} = 3 \text{ cm } H_2O$$

$\boxed{A_g = 0.1 \text{ cm}^2}$

Method 2:

We know $\Delta P_1 = \Delta P_2 = 3$ cm H_2O, and that the volume velocity, U, through the two constrictions is the same. From the $\Delta P = \dfrac{\rho U^2}{2A^2}$ equation, A_g must be equal to A_c in order for the two pressure drops to be equal.

$\boxed{A_g = 0.1 \text{ cm}^2}$

Problem 3

(3) Phonation stops, and bubbles persist: depth: 3-4 cm
Phonation stops, and bubbles stop: depth: 7-9 cm

When both phonation and bubbles stop, it means the subglottal pressure is equivalent to the pressure above the straw level. Thus, the subglottal pressure is approximately 7-9 cm H_2O. The transglottal pressure (P_s - P_m) at the threshold of phonation, when phonation stops but bubbles persist, is approximately 3-5 cm H_2O.

(4) Possible sources of error:
-a constant subglottal pressure might not be maintained during experiment.
-imprecise measurement of water depths.

Problem 4

(a)

1. length	[‘leŋθ]	=>	[‘lɛŋθ]
2. claim	[‘clem]	=>	[‘klem]
3. them	[‘θm]	=>	[‘ðm]
4. strives	[′strαivs]	=>	[′strαivz]
5. fishing	[′fɪshɪŋ]	=>	[′fɪšɪŋ]
6. enjoy	[ən′joi]	=>	[ən′ǰɔi]
7. bellow	[′bɛllo]	=>	[′bɛlo]
8. damage	[′dæmæj]	=>	[′dæmɛǰ]
9. depreciate	[də′pre šiet]	=>	[də′pri šiet]
10. avoid	[æ′vɔid]	=>	[ə′vɔid]
11. recall	[ri′kol]	=>	[ri′kɔl]
12. contain	[kən′tan]	=>	[kən′ten]

13. pleasure [′plɛzer] => [′plɛž ɚ]

14. exemption [əx ′ɛmpšən] => [əgz ′ɛmpšən]

15. thorough [′ðɚo] => [′θɚo]

16. protrude [pro′trUd] => [pro′trud]

17. inhumane [ɪnhu′men] => [ɪnhju′men]

18. understanding [undɚ′stændɪŋ] =>[ʌndɚ′stændɪŋ]

19. insight [′ɪnsit] => [′ɪnsαit]

20. tiptoe [′tipto] => [′tɪpto]

21. doomsday [′domzde] => [′dumzde]

(b)

When the sunlight strikes raindrops in the air, they act like a
[′wɛn] [′ðə] [′sʌnlαit] [′strαiks] [′rendrɔps] [′ɪn] [′ði] [′ɛɚ], [′ðe] [′æk] [′lαik] [ə]

prizm and form a rainbow.
[′prɪzm] [′ə(n)] [′fɔrm] [′ə] [′renbo]

(c)

my name is pronounced xuemin chi.
[′mαi] [′nem] [′iz] [prə′nαunst] [šə′min] [′či].