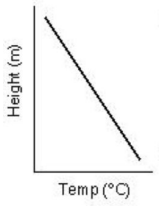
1. **7 points (0.5 each)**

    a. C
    b. B
    c. D
    d. C
    e. C
    f. D
    g. C
    h. A
    i. E
    j. A
    k. B
    l. C
    m. D
    n. E

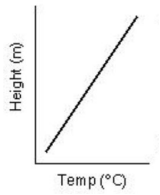
2. C **(1)**
3. D **(1)**
4. A **(1)**
5. C **(2)**
6. E **(2)**
7. C **(1)**
8. A **(1)**
9. C **(1)**
10. C **(1)**
11. D **(2)**
12. E **(2)**
13. B **(1)**
14. D **(1)**
15. D **(1)**
16. E **(1)**
17. A **(1)**
18. D **(1)**
19. C **(1)**
20. A **(2)**
21. E **(1)**
22. C **(1)**
23. B **(1)**
24. D **(1)**
25. B **(2)**

26.

a. (1)



b. (1)



c. **(4)** Mentions for 1 point each:

i. During the day sound bends upwards
ii. During the twilight sound bends downwards
iii. Connects this behavior to camping scenario
iv. Names the phenomenon as “shadow zone” (or similar)

27.

Models clarinet as cylindrical pipe, open at one end and closed at the other **(2)**.

Answer discusses behavior of first and second modes **(1)**

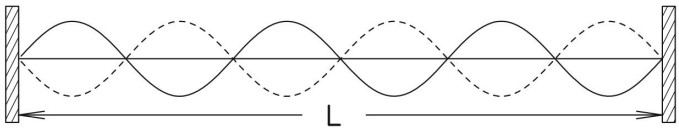
Mentions that there is a node in the second mode one third of the way from the closed end **(1)** ….and then concludes that if a hole is opened at this point in the pipe, the second mode is therefore not affected **(1)**

Mentions that the first mode requires considerable pressure variation one-third of the way from the closed end, and/or that he first mode cannot survive with a hole at that point **(1)**

Concludes that the register-key placement makes sense because the register hole kills off the first mode while not affecting the second mode **(2)**

28.

a. **(5)** Accurate diagram:



b. Five nodes **(1)**

29.

a.
   i. 110Hz **(1)**
   ii. Showing work **(1)**

b. “Fundamental” **(1)**

c. 330Hz **(1)**

30.

a. The frequency stays the same **(1)**

b. The frequency gets smaller by a factor of the square root of two **(1)**

c.
   i. 3.18 Hz **(2)**
   ii. Showing work **(1)**

31.

a. Equal temperament **(1)**

b. $f_i = 261.6x2^{i/12}$ **(1)**

c. 3mm **(2)**

d. (0.5) each:

0: 326mm

1: 290mm

2: 258mm

3: 243mm

4: 216mm

5: 192mm

6: 171mm

7: 161mm

32.

a.

i. For the longest possible cylinder (287 mm), expressing the speed of sound in mm/s, 344000/(4*287) = 299.7 Hz. **(1.5)**

ii. The shortest cylinder is 232 mm shorter, or 55 mm long. Then, 344000=(4*55) = 1564 Hz. **(1.5)**

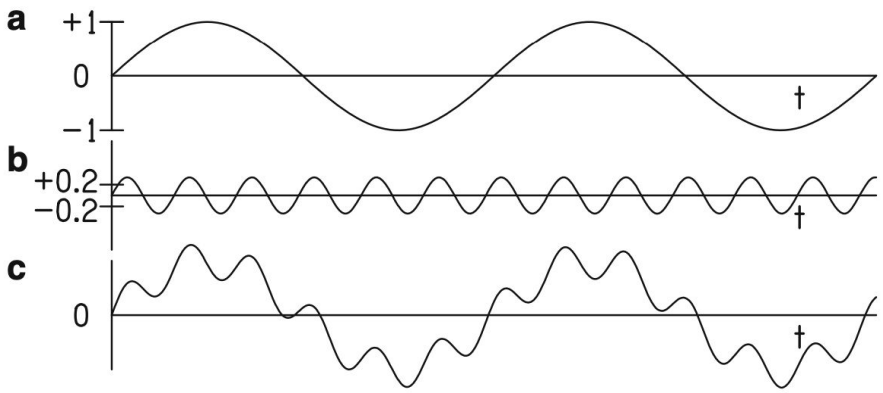
b.

i. Yes **(1).**

ii. Proof: The frequency ratio is 1564/299.7 or 5.2. This ratio is greater than the ratio for two octaves, which would be a ratio of 4. **(2)**

33.

a. **(2)**
b. **(2)**
c. **(2)**



d. x(*t*) = 1.0*sin(2pi*256*t*) + 0.33*sin(2pi*1997*t*) **(2)**

e.

i. The clang modes are rapidly damped. **(1)**

ii. By contrast, the main mode lasts a long time so shortly after the fork is struck, only the main mode can be heard. **(1)**

34.

a. **(0.25 each for 4pts total):**

C_1, C_2, G_2, C_3, E_3, G_3, $B\flat_3$, C_4, D_4, E_4, $F\sharp_4$, G_4, A_4, $B\flat_4$, B_4, C_5

b. Melodic minor scale **(3)**

c. A♭ harmonic minor **(3)**

d. Beethoven 9 **(Extra credit: +1)**