EOES 2023

Task 1
Marking scheme

Song and Dance through eyes of science

EOES2023, 01.05.2023

Problem 1

1.1. *Match the letter corresponding to the correct term, so the sentence below would be correct. (2 p)*

While [1] is not a striated muscle, metabolically it is very close to [2] muscle fibers, that can be also deduced from its high myoglobin content

Box No	Letter (a, b, c)	*Marks*
[1]	*c*	*1*
[2]	*a*	*1*
Total		*2*

Skills required from student:

- *Knowledge that digestion tract consists of smooth muscles*
- *Ability to conclude that red sample corresponds to gizzard*

1.2.1. Write which scheme corresponds to the white muscle fibres (W) and which to the red ones (R). (2p)

Scheme	Letter R or W	*Marks*
Scheme 1	*R*	*1*
Scheme 2	*W*	*1*
Total		*2*

Skills required from student:

- *Text comprehension*
- *Knowledge of lactate contributing to muscle fatigue*

1.2.2. Calculate how many ATP molecules can be produced from 1 glucose molecule in each muscle fibre and how many oxygen molecules would be used (4 p)

Scheme	Number	*Marks*
Number of ATP molecules produced from one glucose molecule in scheme 1	*32*	*1*
Numberof ATP molecules produced from one glucose molecule in scheme 2	*2*	*1*
Number of O_2 molecules used to produced ATP from one glucose molecule in scheme 1	*6*	*1*

Amount of O_2 molecules used to produced ATP from one glucose molecule in scheme 2	*0*	*1*
Total		*4*

Skills required from student:

- *Text and scheme comprehension*

*ANSWERS: Oxidative glucose metabolism - 2 ATP + 2 NADH+H$^+$ + 2 Krebs cycles (1 ATP, 3 NADH+H$^+$, 1 FADH$_2$) = 2 ATP + 8 NADH+H$^+$ + 2 FADH$_2$ = 2 + 2.5*8 + 1.5 *2 = 32*

Anaerobic glucose metabolism 2 ATP (NADH are spent to produce lactate)

Every reduced cofactor gives 2 electrons to the ETC that are accepted by single oxygen. Aerobic metabolism produces 12 reducing cofactors, thus 12/2 O2 molecules are required.

1.3.1.Pick the right cause for bubble formation (1 p)

Letter (a, b, c, d)	*Marks*
c	*1*

Skills required from student:

- *Text and scheme comprehension*
- *Deduction*

1.3.2. Arrange your samples according to their catalase activity, starting from the most active one in decreasing order of enzíme activity. (3 p)

	Letter of the sample (A, B or C)	*Marks*
The most active catalase	*B*	*1*
Catalase with average activity	*C*	*1*
The least active catalase	*A*	*1*
Total		*3*

Skills required from student:

- *Observation*
- *Deduction from observations and general knowledge of mitochondria*

1.3.3. Which of the explanations explains the observed catalase activity differences? (1 p)

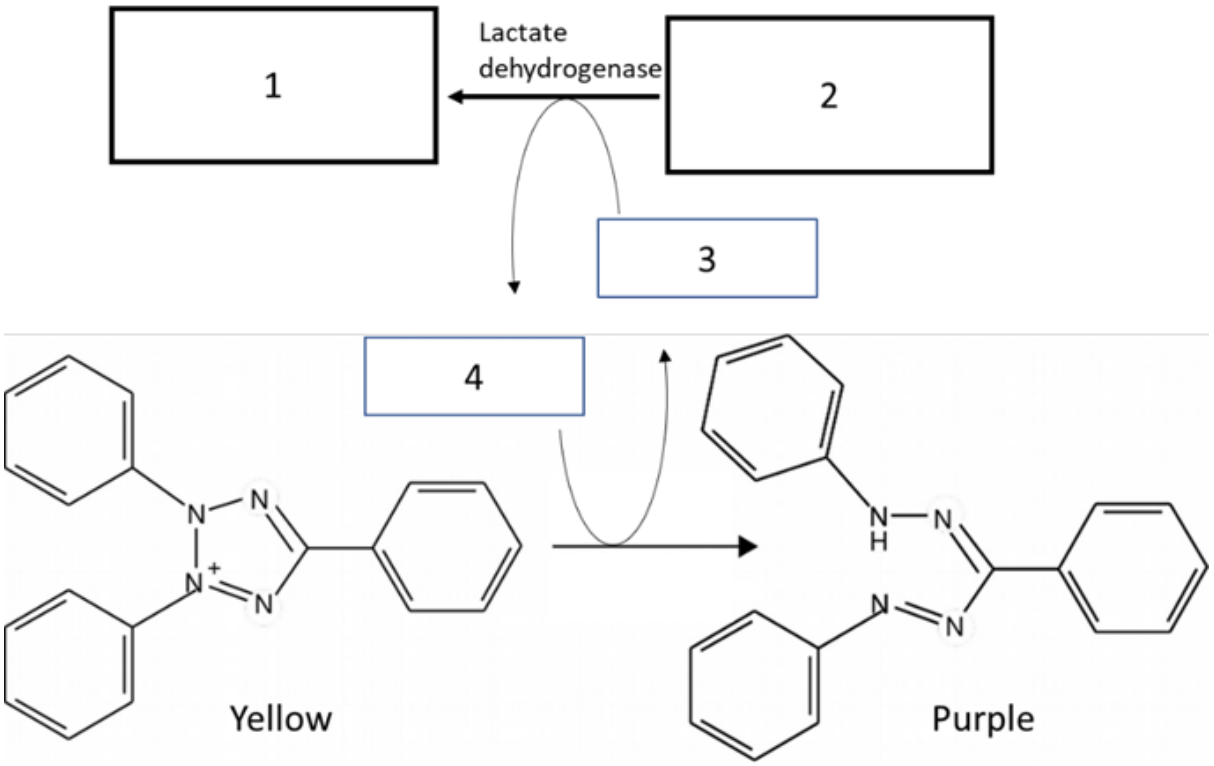
Letter (a, b, c, d, e)	*Marks*

a	*1*

Skills required from student:

- *Text and scheme comprehension*

1.4.1. Complete the reaction scheme by writing the correct reactants in the correct boxes (2 p)



Choices: A - lactate; B - pyruvate; C- NAD^+; D - $NADH+H^+$; E - ATP; F - ADP

Number	*Letter*	*Marks*
1	*B*	*0.5*
2	*A*	*0.5*
3	*C*	*0.5*

4	*D*	*0.5*
Total marks		*2*

Skills required from student:

- *Text and scheme comprehension*

1.4.2. Sample correctly prepared

Letter of the sample	*Mark*	*Signature of lab assistant*
A	*1*	
B	*1*	
C	*1*	
Total	*3*	

Skills required from student:

- *Practical skills*

1.4.3. Fill in the table with your recorded results, use provided numbers to code the colours (6 p)

Yellow	*Orange*	*Red*	*Brown*	*Purple*
1	*2*	*3*	*4*	*5*

	A	*B*	*C*	*A1*	*B1*	*C1*
0.5 minutes						
1 minute						
1.5 minutes						
2 minutes						

2.5 minutes						

Marks for this task

2 p data entered in table and matches observations

1 p A1 the most active sample from a1-c1

1 p B1 the least active sample form a1-c1

1 p A the most active sample from a-c

1 p B the least active sample form a-c

For EOES2023, full points given if anything written in table. Next two questions graded according to table

Total	*6*

Skills required from student:

- *Practical skills*

Confirmation of the results. Signature of lab assistant _____

1.4.4. Arrange samples A1-C1 according to their lactate dehydrogenase activity, starting from the most active one.(3 p)

	Letter of the sample (A, B or C)	*Marks*
The most active catalase	*A*	*1*
Catalase with average activity	*C*	*1*
The least active catalase	*B*	*1*
Total		*3*

Skills required from student:

- *Observation*
- *Deduction from observations*

1.4.5. Compare the protein concentration in samples A and A1 based on your enzyme activity by using >, =, < symbols (1 p)

	Compare >, =, <		*Marks*
Protein concentration of A1 is		*than in A*	*1*

Answer depends on 1.4.3. table

Problem 2

2.1.1. Indicate the best wavelength to use for measuring haemoglobin concentrations (1 p)

Letter (A, B, C, D)	*Marks*
B	*1*

2.1.2. Write concentrations of haemoglobin solutions you have prepared, considering that the STANDARD haemoglobin solution's concentration is 1,0 g/L (3p)

Show calculation of concentration for tube 1

Calculation	*Marks*
	1

1p if correct calculation

Tube No	*Concentration, g/L*	*Marks*
Standard solution	*1*	*2*
1	*0.5*	
2	*0.25*	
3	*0.125*	
4	*0.0625*	
5	*0.03*	
6	*0.015*	

0.5 p for correct initial concentration, 1 p that concentrations serially differ with 2x step, 0.5 p correct numbers

Both rounded and unrounded results are accepted

2.1.3. Write measurements that you obtained (4.5 p)

Tube No	*Absorbance, AU*	*Marks*
Standard solution		*1.5*
1		*0.5*
2		*0.5*
3		*0.5*
4		*0.5*
5		*0.5*
6		*0.5*
Total		*4.5*

0.5p for each correct measurement with two decimal places, +/- 1, 1p for correct calibration (compared with standard solution measurement performed by jury)

We measured hemoglobin soulution with all available spectrophotometers and we accept all answers from 1,1 - 0,85 as the first A for undiluted sample, afterwards 0.5 points are awarded if A is around ½ of previous A (+/- 30%)

2.1.4. *See millimetre paper (6 p)*
1 p for axis names, 1 p for units of measure added to axis, 1 p for correctly placed data points, 1 p calibration curve drawn, 1 p calibration curve crosses 0, 1 p for a careful graph from which accurate readings can be made,

2.1.5 *Preparation of diluted samples. Write how much water you should add and what will the dilution coefficient be in this cuvette (2 p)*

	Answer	*Marks*
Water, microliters (uL)	*800*	*1*
Dilution coefficient, k	*5*	*1*
Total		*2*

2.1.6. *Write measurements that you obtained (3 p)*

Sample	*Absorbance, AU*	*Marks*
A		*0.5*
B		*0.5*
C		*0.5*
A1		*0.5*
B1		*0.5*
C1		*0.5*
Total		*3*

0.5 points for any value in A-C, 0.5 if value of A1-C1 matches measurement that we performed afterwards A1 we accept A 0,7-1,8, B1 0,9 - 1,2, C1 1,0 - 1,6

2.1.7. *Fill out the table if additional measurements are needed and state why (3 p)*

Sample	*Additional measurement needed (Y/N)*	*Reason for additional measurement -* *1 - out of calibration curve* *2 - out of apparatus measuring abilities*	*Marks*
A			*0.5*
B			*0.5*
C			*0.5*
A1			*0.5*
B1			*0.5*
C1			*0.5*
Total			*3*

0.5 p for each correct conclusion according to the students data

2.1.8. *Fill out the table for samples that needed additional dilutions (2 p)*

Sample	*Amount of sample, microliters*	*Amount of water, microliters*	*k*	*A, AU*	*Marks*
					2

2 p if all calculations are correct. 1 p if a mistake is made in less than half of the calculations.

2.1.9. Using your calibration curve, measured absorbance of diluted samples and calculated *k*, calculate initial concentration of myoglobin in each sample. *(7 p)*
Show calculation of concentration for sample A

Calculation	*Marks*
	1

1p if correct calculation

Sample	*[Myoglobin], g/L*	*Marks*
A		*1*
B		*1*
C		*1*
A1		*1*
B1		*1*
C1		*1*
Total		*7*

1 p for each correct answer from students data

2.1.10. *Indicate which muscle (A, B, C) (A1, B1, C1) will have the largest oxygen reserves. (1 p)*

Letter	*Marks*
A	*1*

Both tissue with highest absorbance and gizzard sample is considered correct

Problem 3

3.1. *Write the results of your measurements*

Specimen	*Initial weight, g*	*Weight after burning, g*	*Water temperature before burning, °C*	*Water temperature after burning °C*

Total	*8*

1 p for mass measurements with same precision
1 p temperature measurements with same precision
1 p for emptying water between measurements (2 mistakes allowed)
At least 4 specimens of a product measured, 1p each product

Believable mass measurements (1 p), Believable T measurements (1 p)

3.2. *Calculate the energetic value of all food items from your data in kcal/100g, write your answers in the answer sheet. Show your calculation for potato crisp.*

Calculation	*Marks*
	3

1 p for calculating temperature difference, 1p for taking in to account mass of water and crisp, 1p for converting to correct dimension

Other approaches also considered as correct

	Potato crisp	*Rice galette*	*Corn puff*	*Marks*
kcal/100g				*3*

1 p for each result according to the measurements

3.3. *Mark to which forms of energy chemical energy contained in glucose is converted in each case.*

Condition	Letter (A, B, C)	*Marks*
Metabolic activity	*A*	*1*
Burning	*C*	*1*

3.4. *Mark if aerobic (A) or anaerobic (N) metabolism is closer to burning*

Letter	*Marks*
A	*1*

3.5. *Evaluate sentences in the task sheet and propose which is the correct one*

Letter (A, B, C, D)	*Marks*
A	*1*

3.6. *Estimate, which nutrient has the highest caloric value per mass:*
A: Fats, B: Carbohydrates, C: Proteins, D: Salt

Letter (A, B, C, D)	*Marks*

A	*1*

In case of untranslated answer sheet B accepted

3.7. *Write letters corresponding to the processes why your would give you less calories than on packaging (2 p)*

Letter (a, b, c, d, e, f)	*Marks*
A, B, C, D	*2*

0.5 p each

Problem 4

4.1. *Deduce if vocal cords are open (A) or closed (B), when breathing (1p)*

Letter (A or B)	*Marks*
A	*1*

Skills required from student: knowledge on the functions of respiratory system

4.2. *Deduce which muscles will open and close the vocal cords if contracted. Which muscle will change the length of the vocal cords?*

State after muscle contraction	*Letter of the muscle (A, B, C)*	*Marks*
Opens vocal cords	*B*	*1*
Closes vocal cords	*A*	*1*
Shortens vocal cords	*C*	*1*
Total		*3*

Skills required from students: deduction of how muscle position contraction influences the length of the vocal cords.

4.3. *Describe your observations in the answer sheet.*

Sound	*Vibration of larynx (+ present, - absent)*	*Vocal cords open (A) or closed (B)*	*Marks*
[f]	*-*	*A*	*1+1*
[v]	*+*	*B*	*1+1*
Total			*4*

Skills required from students: synthesis of 4.1. and observations

Task 5

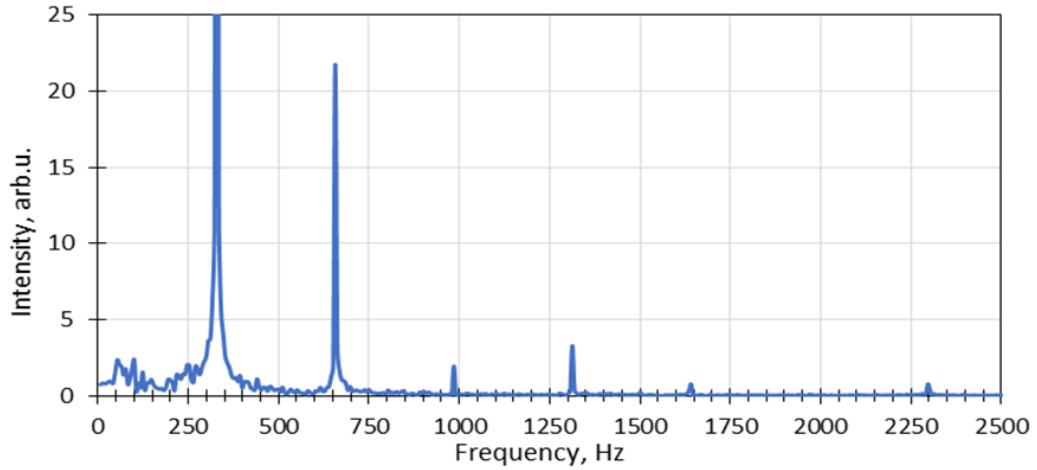
5.1.1. *Write the fundamental frequency (the first harmonic) of this particular string on a guitar? (1 p)*

Frequency, Hz	*Marks*
330 Hz [accept answers in the range 300 Hz to 350 Hz]	*1*

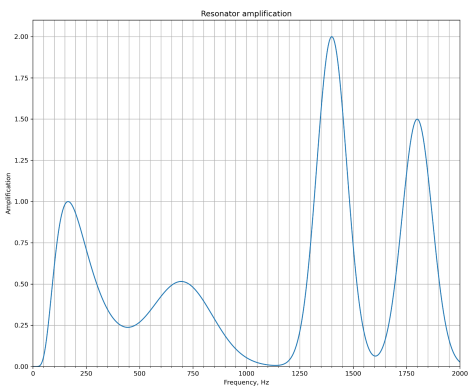
5.1.2. *Write how many harmonics can you see in the spectra and what their frequencies are? (3.5 p)*

	Answer	*Marks*
Number of harmonics	*6*	*0.5*
		0.5 for each correct
Total		*3.5*

5.1.3. *Write in the answer sheet are all the possible harmonics within the frequency range 0-2500 Hz present. If not - sketch in the graph where the missing harmonics would be? (1.5 p)*

	Answer	*Marks*
Are all the harmonics present (Y- yes, N - no)	*N*	*0.5*
		*1* *0.5*
Total		*1.5*

5.1.4. *Determine and sketch the shape of the resonator response (4 p)*

	Answer	*Marks*
Sketch the shape of the resonator response		*4*

Points	**Special cases**
2pts - if all peaks positioned correctly (150-200Hz, 700Hz, 1400Hz, 1800Hz) [*0.5pts for each peak*] **2pts** - if relative intensities appropriate (heights in correct order, approximate amplitudes: 1.0; 0.5; 2.0; 1.5) [*0.5pts for each peak*]	**-0.5p** - If only points shown with no curve (so the precise maxima locations are difficult to assess) deduct 0.5 pts from total

5.1.5. *What are the frequencies of the first two formants for this resonator?*

	Answer	*Marks*
f_1	*165 Hz*	*0.5*
f_2	*700 Hz*	*0.5*
Total		*1*

Answer: F1=165 Hz, F2=700 Hz.
0.5 points for each correct frequency +- 10%

5.2.1. *If you increase the length of the reed that is poking out of the stopper, the frequency of the duck call increases, decreases or stays the same? (1p)*

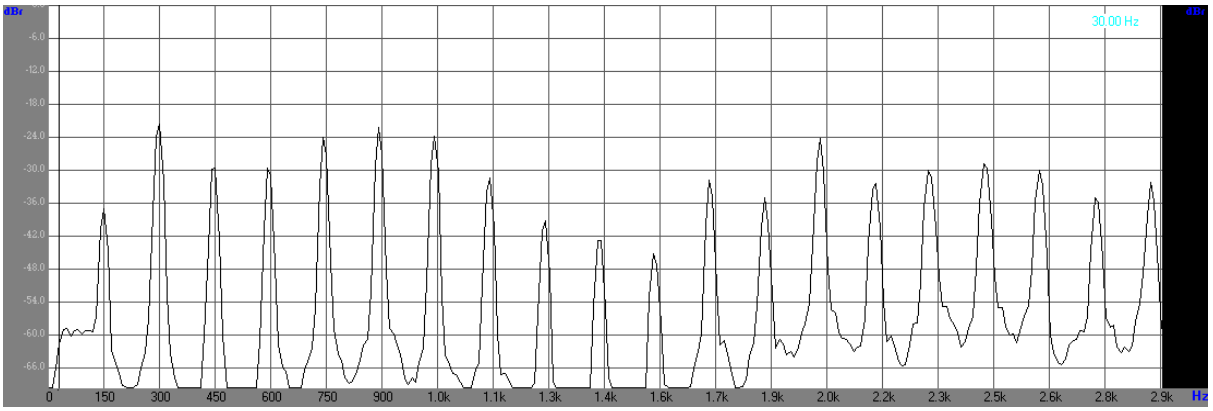
	Answer	*Marks*
Check the correct box	*[checkboxes]* ☐ *increases*	

	☒ *decreases* ☐ *stays the same*	

1 Point if the correct qualitative relationship is captured - increasing length decreases frequency.

5.2.2 *Adjust the reed position so that the duck call produces a sound with the fundamental frequency of 150 Hz. Measure the spectrum of the duck call sound, making sure that the frequency peaks are well-defined and not "fuzzy". Rename the spectrum as "duck_call_YOURCOUNTRY.bmp". (4 p)*

Answer:

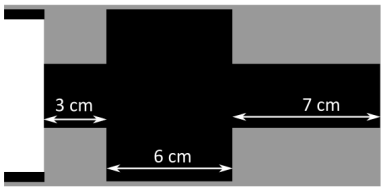


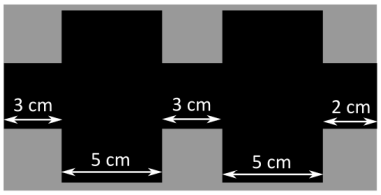
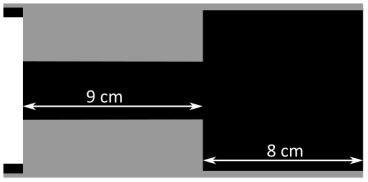
Points	***Special cases***

***1pts** - spectrum created* ***2pts** - fundamental frequency in range 135-165Hz [1pt if fundamental in range 120-170 Hz, 0pts if fundamental not in given ranges]* ***1pts** - all harmonics in 3 kHz range visible*	*Award only 0.5 pts for spectrum creation if frequency axis not visible* *Award 0 pts if the fundamental cannot be reasonably determined (frequency axis not shown (and no marker) or wrong (log) scale for frequency axis)* *If the spectrum is of good quality and only one/two harmonic at the end range are missing, award the full 1 pt for harmonics* *Award 0 pts for harmonics if the intensity is too low for high-frequency harmonics to be visible or if the spectrum becomes noisy for higher frequencies* *Award 0 pts for harmonics if it cannot be assessed due to log scale (.ini not used)*

Total	*4*

***5.3.1** Look at the models for the three vowels below and match each of the models to the corresponding vowel based on what you can identify in the MRI scans. (3 p)*

	Answer ([ɑ], [i], [u])	*Marks*
	*I*	*1*

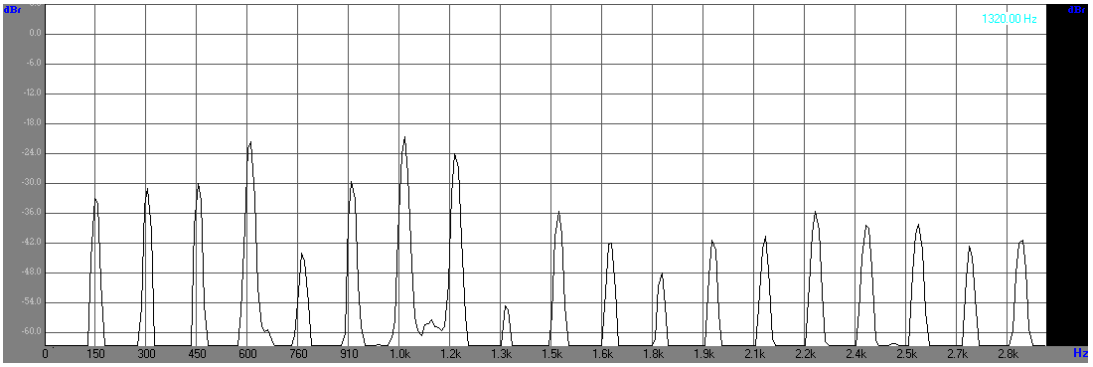
	U	1
	A	1
Total		3

5.4.1. *Measure the spectra of the sound produced by the duck call and filtered through the a, i, u vowel resonators. Make sure that the frequency peaks are well-defined and not "fuzzy". Rename the spectra as "resonator_a_YOURCOUNTRY.bmp", "resonator_i_YOURCOUNTRY.bmp", "resonator_u_YOURCOUNTRY.bmp" for each of the corresponding a, i, u vowel resonators. (6 p)*

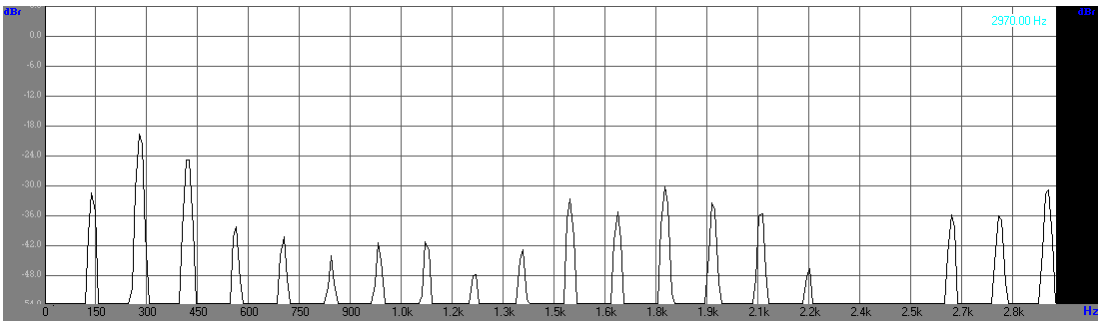
Wovel	*Points awarded by evaluator*	*Marks*
[a]		*2*
[i]		*2*
[u]		*2*
Total		*6*

Answers:

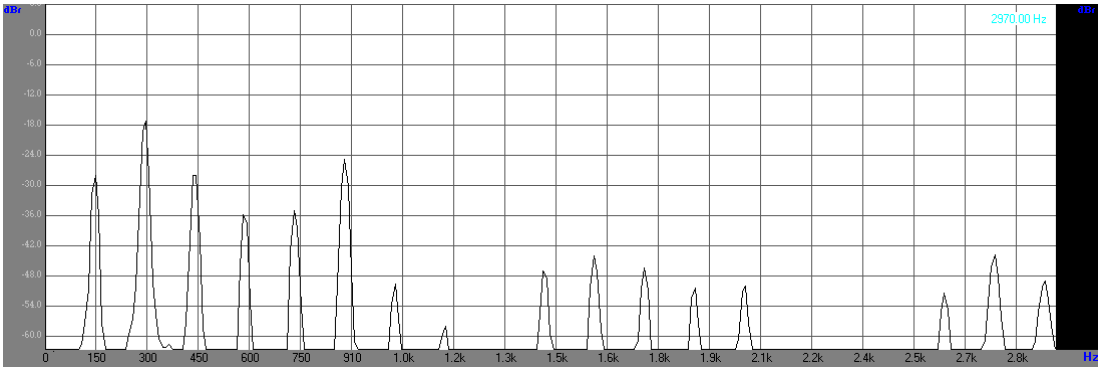
resonator_a



resonator_i



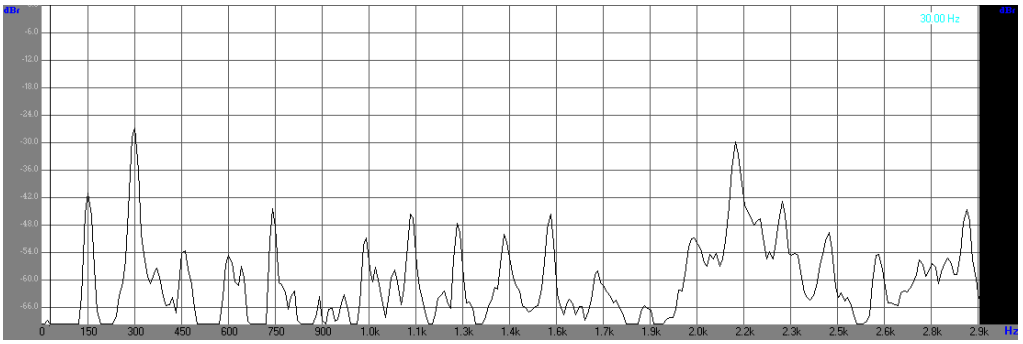
resonator_u



For each spectrum:1 point for the creation of file unless it is way off

"Usually this means that 3 pts are guaranteed if there is a measurement file. Unless it is completely non-usable, such as nothing but noise."

1 point if the peaks are well pronounced and not fuzzy
Example of fuzzy peaks:

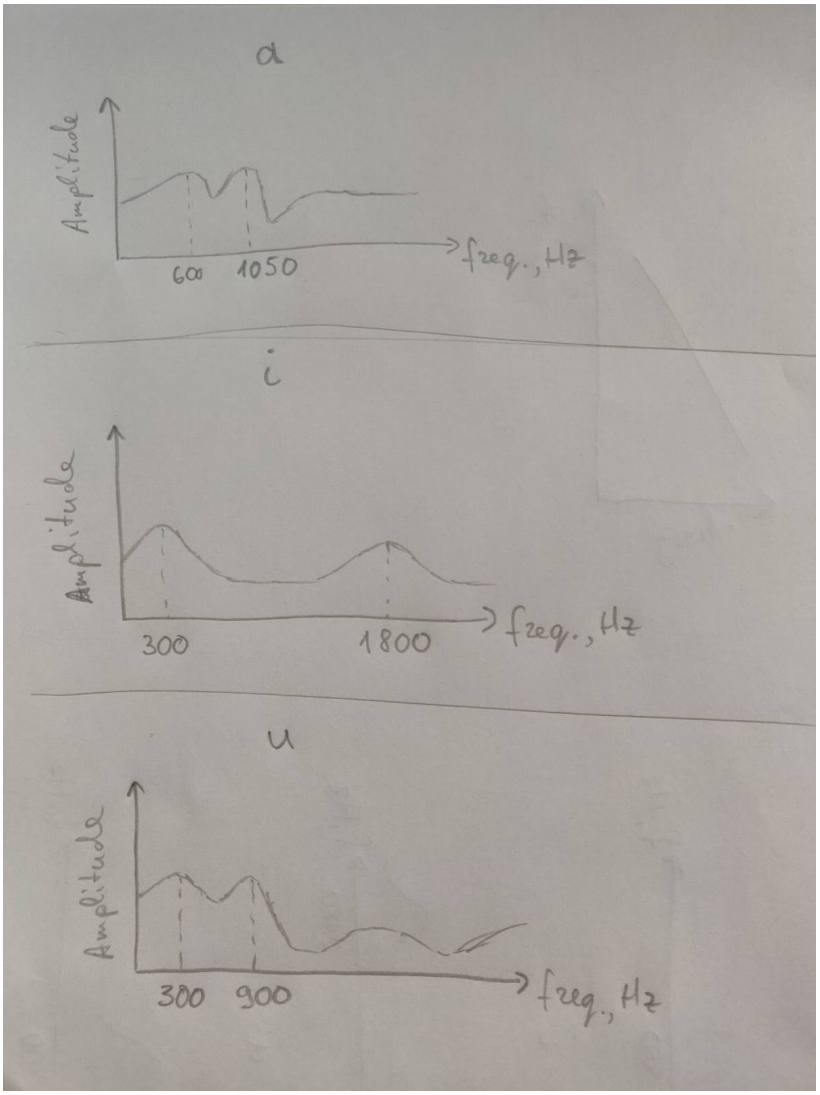


5.4.2. *Compare the spectrum of the pure sound from the duck call with the spectra of the sound filtered through the [ɑ], [i], [u] vowel resonators. Make three sketches of the amplification v.s. frequency of the resonators - one for of each vowel ɑ, i, u. The scale of the*

amplification axis is arbitrary. For each sketch, below the first and second formant write down their approximate frequencies. (6 p)

Wovel	*Your sketch*	*Marks*
[a]		*2*
[i]		*2*
[u]		*2*
Total		*6*

Answer:



For each sketch:
1 point if the first formant frequency corresponds within 20% of the one in the corresponding spectrum
1 point if the second formant frequency corresponds within 20% of the one in the corresponding spectrum
Note: compare these graphs with the spectrum of the student. The student spectrum could have different peaks compared to the ones in these answers.

“

We look at the first two peaks in the student’s drawn amplification graph. For each peak, we compare them with the duck call and duck call + resonator spectrum to see if there is indeed amplification at that frequency +- 20%. A point is awarded if it is the case.

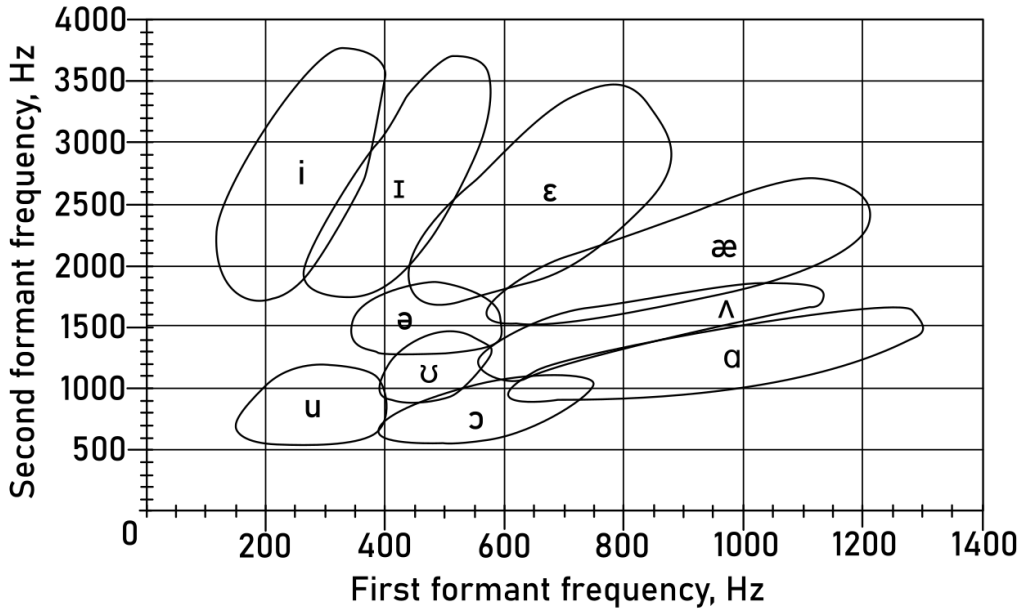
If there is a noticeable amplification region below the ones that the student has indicated, a point is subtracted, since the formant has not been captured.

If the duck call spectrum is not available, unfortunately 0 points are given since without it, the resonator amplification response cannot be determined.

If the written down peak frequencies don’t match the drawn maxima, we used the drawn maxima.

”

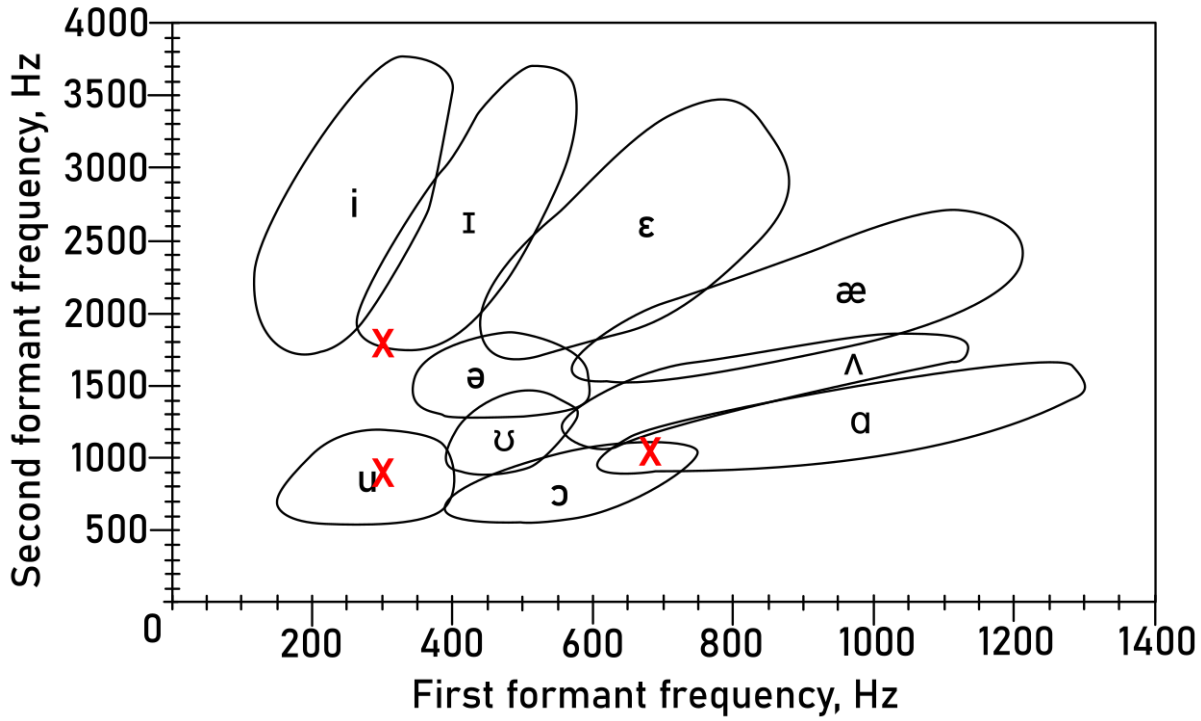
5.4.3. *Using your sketch of the amplification of each resonator, determine the first two formant frequencies for each ɑ, i, u vowel resonator. Mark them down as points in the vowel chart (Figure 4.1.).* *(3 p)*



Marks

3

Answer:



1.5p. if the values in the previous task are marked approximately in the chart.
0.5p. for each:
[a]: F1 between 600 and 1000 Hz; F2 between 900 and 1400 Hz
[i]: F1 between 200 and 400 Hz; F2 between 1700 and 3000 Hz
[u]: F1 between 200 and 400 Hz; F2 600 and 1000 Hz

Note: for the F1 and F2, you can use the sketches from the previous task instead of reading them from the points vowel chart.

“

We gave 0.5 points for each correctly placed point in the vowel chart. The correct point is the one determined in 5.4.2. task from the peaks.

We gave 0.25 points for the first and second formant in the given frequency range. For this evaluation, the formant frequencies are determined from 5.4.2 task peaks and not from the placed points in the vowel chart.

The points are rounded up to the nearest 0.5.

”

5.5.1 *What is the vowel that produced this spectrum? (3p)*

Answer	*Marks*

[u]	*1*

5.5.2 *What is the vowel that produced this spectrum?*

Answer	*Marks*
[i]	*1*

5.5.3 *What is the vowel that produced this spectrum?*

Answer	*Marks*
[ɑ]	*1*