



# FLEET

ARC CENTRE OF EXCELLENCE IN  
FUTURE LOW-ENERGY  
ELECTRONICS TECHNOLOGIES

## JMSS-FLEET unit evaluation 2023

This report is an evaluation of the John Monash Science School FLEET unit on future electronics for the year 2023. The report is based on analysis of the 2023 student survey. Because of exams, students were unavailable for interview this year. Two extra questions were inserted into the survey completed by all students to gather some of the data that is normally obtained from interviews.

### Highlights

- About 86% of students enjoyed and found the unit interesting.
- About 84% of students thought that the topics should be kept in future years.
- About 26% of students perceive that their experience with the FLEET unit has made them consider studying physics-based subjects in the future.
- FLEET scientists are crucial with 88% ranking highly the value of FLEET scientist for their role in helping students develop new perspectives on physics and facilitating an increased breadth and depth of understanding of the topics taught.

### Overview of the FLEET unit

The FLEET unit introduces the John Monash Science School (JMSS) Year 10 students to quantum physics at an intuitive level (with minimal maths) and expands on this fundamental understanding to explain complex, useful quantum states such as superfluids and topological materials.

JMSS conducts the unit as an elective over one semester. The unit covers to varying extents the following topics:

- Conductors, Insulators and Semi-Conductors
- Binary, Transistors and Boolean Logic
- Momentum and Kinetic Energy
- Quantum physics
- Topological materials
- Superfluids and excitons
- Particle physics
- Heat and Temperature



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- Graphene and Cold Atoms
- Electromagnetics

The bulk of the unit is taught by JMSS physics teachers with FLEET members providing guest presentations. Most presentations by FLEET members were conducted in-person. FLEET conducted presentations for the students on the following topics:

- Unit introduction. Introduction to FLEET, its research and an outline of the unit
- Transistors and semi-conductors
- Quantum physics
- Quantum computing
- Cold atoms
- Topological materials
- Graphene
- FLEET lab tours.

## Evaluation

Each year, the JMSS students who have done the FLEET unit complete a survey to evaluate aspects of the unit. In 2023, 29 students completed the survey. The survey contains quantitative Likert-like scales and open-ended questions. The Likert-like scales used in the following questions assess the specific topics in the unit:

- I found this topic interesting
- I enjoyed this topic
- I found this topic difficult
- This topic was presented in a way I could understand
- I would keep this topic in the course in future years

The following Likert-like questions applied to the unit overall:

- Would this course increase the chances that you might choose to study relevant subjects in the future?
- If you didn't choose to pursue a career in Physics, Electronics or Computing, do you believe that the topics that you have learned about in this course be useful anyway?



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The following questions used a ranking from 1-4 where 1 is ranked 'most valuable' and 4 being 'no value'

- Was it valuable to get to hear from and work with FLEET scientists?

The open-ended questions are as follows:

- How has the FLEET unit has made you think about and value of physics broadly as a discipline and specifically as a potential career for yourself?
- Regarding these FLEET scientists that help present the unit. Describe the value that these people brought to the unit, your understanding of the topics and how you value physics broadly?
- What did you like most about the course?
- What would you change about the course to improve it?

#### Aims of the evaluation

The survey evaluates student enjoyment of the unit and how they value it. More specifically for FLEET, a greater emphasis for the evaluation is to increase FLEET's understanding of the following:

- The unit's effect on student perceptions about the value of physics as a discipline
- The unit's effect on how students value physics as a career option (or its usefulness in a career)
- How students value FLEET presenters and how well the presenters facilitate the achievement of the above aims.
- \*The impact of female FLEET presenters on female students' perceptions of physics as a career option.

\*Note that the impact of female presenters on female students' perceptions on physics as a career option has been a focus in the semi-structured interviews in 2021 and 2022. Because no interviews could be conducted this year, we were unable to gather data on this objective.

This evaluation first examines the quantitative Likert-like survey questions, then the open-ended questions.

## Results

Results outlined here are summaries of the main findings. Detailed graphs of each of the Likert-like survey questions can be found in Appendix 1. The Likert scales were Agree – Partially agree – Partially disagree – Disagree. The exception, as noted above, is the question, Was it valuable to get to hear from and work with FLEET scientists?

## Likert-like questions

### I found this topic interesting

Students typically found the topics taught in the unit interesting. About 86% of students agreed or partially agreed that the topics were interesting. While still high, it is somewhat less than 2022 figure of 96%. See Table 1.

Based on students who selected 'agree', Quantum physics was again the topic students found most interesting with 66% of students selecting agree. If the scales of Agree and partially agree are combined then the topics of most interest were Quantum and Binary, transistors and Boolean logic where 90% agreed or partially agreed they found the topics interesting. See Appendix 1.

Table 1. Level of agree on how interesting JMSS participants found the topics in the FLEET unit.

Level of agreement	Agree	Partially agree	Partially disagree	Disagree
Number of students	84	65	19	5

### I enjoyed this topic

Enjoyment reflects interest in the topics and the results for enjoyment of the topic are similar to the topic being interesting. About 80% of the students agreed or partially agreed they enjoyed the topics. See Table 2. In 2022, this figure was 90%. Momentum and Quantum were the two topics students enjoyed most where 79% and 83% of students respectively agreed or partially agreed that they enjoyed the topics. See Appendix 1.

Table 2. How JMSS students ranked their enjoyment of the FLEET unit topics

Level of agreement	Agree	partially agree	partially disagree	disagree
Number of students	70	69	27	6

### I found this topic difficult

Students typically did find the topics difficult and their perception of difficulty varied between topics, but as suggested by their their high level of interest and enjoyment, the difficulty of the topics did not affect their interest or enjoyment. For example, students ranked Quantum physics as one of the more difficult topics yet it was also rated highly for enjoyment and interest. See Table 3.



Table 3. How JMSS student ranked the level of difficulty of the FLEET unit topics

Level of agreement	agree	partial agree	partial disagree	disagree
Number of students	27	53	64	27

### The topic was presented in a way I could understand

Overall the students thought the topics were taught in a way they could understand. Similar to 2022, about 88% of students agreed or partially agreed that the topics were taught in a way they could understand.

There were only two topics (Conductors, insulators and semi-conductors and Quantum) where there was any significant perception that the topic was difficult to understand, and most of those perceptions only partially agreed the topics were difficult. See Table 4.

Table 4. Level of JMSS students' agreement on whether the JMSS unit topics were presented in a way that was understandable

Level of agreement	agree	partial agree	partial disagree	disagree
Number of students	91	56	24	4

### I would like to keep this topic in future years

Most students (84%) agreed or partially agreed that the topics should be kept in future years. There was marginal variation between topics for this question.

### Would this course increase the chances that you might choose to study relevant subjects in the future?

Compared to 2022, a smaller number of students in 2023 considered that the FLEET unit increased their chances to study subjects relevant to the unit in the future. In 2023, only 26% of students considered the FLEET unit made them consider studying such relevant subject. This figure in 2022 was 55%. The lower figure might have been affected by the fact that a greater proportion of students in 2023 compared to 2022 (37% in 2023 compared to 28% in 2022) were already planning to study these topics in the future.

A significantly higher proportion of students in 2023 compared to 2022 and 2021 perceived the FLEET unit had no effect on what subjects they wanted to study in the future. See Table 5 and Figure 1 below.

Table 5. JMSS Year 10 FLEET unit evaluation 2023. Student question: Would this course increase the chances that you might choose to study relevant subjects (ie: Physics, Electronics, Computing) in the future?

Student response	% of students (2022/2021 data)
Yes - It has made me consider doing these subjects in the future	26% (55% / 36%)
I was already planning to pursue study in these fields in the future	37% (28% / 46%)
No - It has had no effect on what I wanted to do in the future	37% (16% / 17%)

Would this course increase the chances that you might choose to study relevant subjects (ie: Physics, Electronics, Computing) in the future?

34 responses

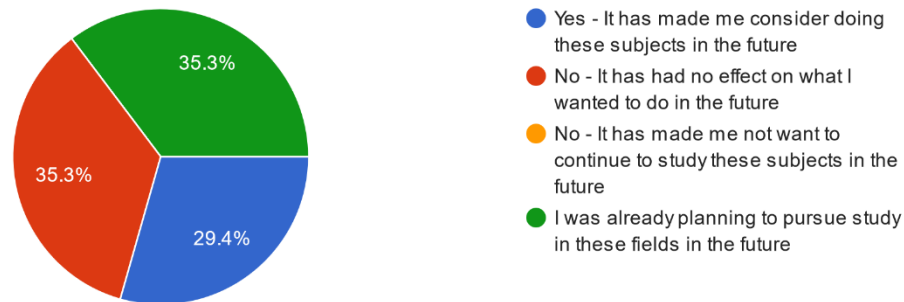


Figure 1. 2023 data on proportion of students that, because of the FLEET unit, are considering studying relevant subjects



**If you didn't choose to pursue a career in physics, electronics or computing, do you believe that the topics that you have learned about in this course will be useful anyway?**

Most students (55%) in 2023 thought that all or most of what they learned in the unit would be useful outside a physics-based career. About 41% of students, however, considered that what they learned would only be somewhat useful and 3% didn't think it be useful at all. The results did not vary greatly from those of 2021 and 2022. See Table 6 and Figure 2. Below.

Table 6. JMSS Year 10 FLEET unit evaluation 2023. Student question: If you didn't choose to pursue a career in physics, electronics or computing, do you believe that the topics that you have learned about in this course be useful anyway?

<b>Student response</b>	<b>% of student in 2023 (2022/2021 data)</b>
Yes - all of it is useful and/or interesting	14% (14% / 17%)
Yes - most of it was useful and/or interesting	41% (58% / 56%)
Somewhat - some of the topics were useful and/or interesting but some were not	41% (25% / 20%)
No - I didn't think the majority of the topics would be useful and/or interesting	3% (3% / 7%)

If you didn't choose to pursue a career in Physics, Electronics or Computing, do you believe that the topics that you have learned about in this course be useful anyway?

36 responses

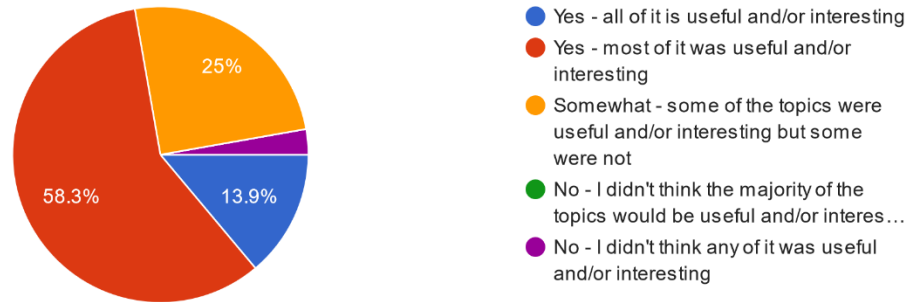


Figure 2. 2023 data assessing students' belief that the topics that they learned about in the FLEET unit will be useful anyway

### Was it valuable to get to hear from and work with FLEET scientists?

Most students highly valued their interaction with FLEET scientists with about 88% entering a ranking of 1 or 2. See Table 7 and Figure 3.

Table 7. Ranking of how JMSS students in the FLEET unit value hearing from FLEET scientists

Ranking (1=high value; 4 = no value)	1	2	3	4
Number of students	19	11	5	0



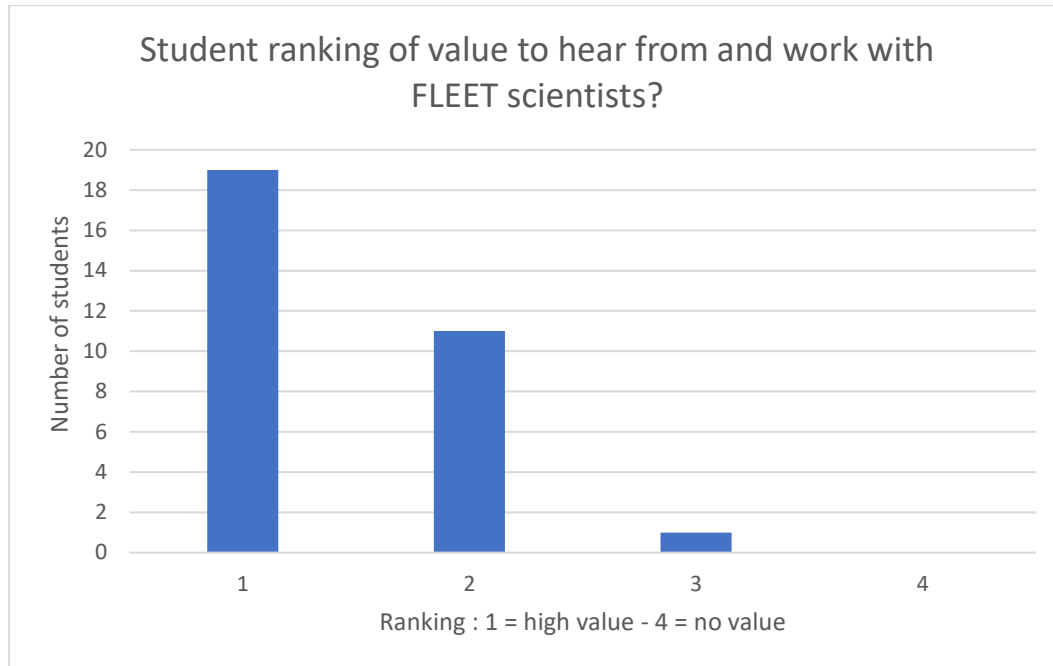


Figure 3. How JMSS students in the FLEET unit rank the value of hearing from FLEET scientists

## Qualitative, open-ended questions

### Q. What did you like most about the course (N=29)

There was a diverse set of responses with students liking the practical components and the fact they were learning new stuff outside of the curriculum. Four students commented on how they valued the FLEET presenters. This student response below summed up a lot of the responses.

The guest presenters on quantum physics, a lot of the quantum physics content, as well as a better understanding of how computers function. I also liked the general rationale behind the course, as I think that FLEET is an incredibly important field of research.



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**Q. How has the FLEET unit has made you think about and value of physics broadly as a discipline and specifically as a potential career for yourself? (N=26)**

The following five core themes emerged from the responses to this question: Gaining breadth, depth of understanding of physics; Shifting career interests toward physics; Higher value on physics; Continuing, reinforcing aspirations; and Presenter influence – can't be what you can't see.

The most responses were about the effect of the unit on students' new insights into the breadth and depth of physics and the career opportunities available. This suggests the FLEET unit has facilitated students' awareness of the relevance of physics to solving some of the world's problems such as energy and climate change. At least six students are also now considering physics as a career option following their experience in the FLEET unit. Another five students formed a greater appreciation for physics as a discipline because of their FLEET unit experience.

Themes

**Gaining breadth, depth of understanding of physics (N=9)**

Students perceived they got a better understanding about the discipline of physics and the career opportunities available. See relevant student responses below.

It has made me realize that physics is a lot more about understanding a deeper concept of the world around us, and there's a lot more to learn as well as discover.

It has helped me understand how important physics is for everything, especially many scientific careers.

It gave me more knowledge about applications of FLEET topics like graphene and superfluidity and how they can be used in different areas.

**Shifting career interests toward physics (N=6)**

Students became more interested in pursuing physics as a career or at least to take it as a subject in VCE or university. See relevant student responses below.

It made me more interested in the career of physics, and as a discipline it has helped me improve a lot in this area.

FLEET has made me consider research, especially in physics, as a potential career through meeting people who work in research and demonstrating that it is possible.



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### **Higher value on physics (N= 5)**

Following the unit, students placed a higher value on physics as a discipline and its relevance to the world they interact with. See relevant student responses below.

It has made me value it slightly more, as it's necessary to solve the future energy crisis.

It has made me appreciate the principles and rules of physics used in places where it is hidden and around us.

### **Continuing, reinforcing aspirations (N=4)**

For students that already had an interest in physics or were considering it as a career option, their experience in the unit reinforced those aspirations and interest. See relevant student responses below.

I already wanted to go for a career in physics, but it has helped my understanding and helped me make sure that I want to go into the course.

Made me more interested in computational physics.

### **Presenter influence – can't be what you can't see (N=2)**

FLEET presenters affected students' perceptions of physics, even inspired at least one to consider a career in physics research. See relevant student responses below.

FLEET has made me consider research, especially in physics, as a potential career through meeting people who work in research and demonstrating that it is possible.

The guest speakers helped us explore the world of physics!!

### **Q. Regarding these FLEET scientists that help present the unit. Describe the value that these people brought to the unit, your understanding of the topics and how you value physics broadly?**

Although there were two responses about FLEET presenters appearing rushed or repeating content they had done with the JMSS Immersion day, which affected what students got from the experience, the overwhelming majority of the responses are positive. Most responses relate to how the FLEET presenters provided students with a new perspective on physics as a discipline and career, and improved understanding of the topics they were being taught. There was some reference to FLEET presenters providing students with a broader and deeper understanding about the career option in physics.

The following four core themes and one sub-theme emerged from the responses: New perspectives, improving understanding (sub-theme: Valuing presenter knowledge, expertise); Gaining breadth, depth of physics – career; Simply interesting.



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## Themes

### **New perspectives, improving understanding (N=18)**

Students perceived the FLEET presenters gave them new and deeper understanding of the topics and new perspectives on physics regarding its relevance to technologies they interact with on a daily basis. See relevant student responses below.

It has opened my eyes to topics that I never thought of before, and changed the way I view computers, AI and their functions

These scientists gave powerful insight to the applications of the topics in the field and provided an opportunity to ask questions specific to the topic.

These people brought an extra perspective and explanation to the topics and helped me understand the content better.

They brought a more expert explanation of the topics which contribute greatly to my deep understanding of the topics.

### **Sub-theme: New perspectives, improving understanding - Valuing presenter knowledge, expertise (N=6)**

While acknowledging that FLEET presenters helped them understand the topics better, they made specific reference to the FLEET presenters' expertise and how much they valued having an expert or real scientist give them insights into their careers and how their research was linked to solving real world problems. See relevant student responses below.

Despite them being a little rushed due to the time limit, it allowed me to understand that there are people with very important careers in this subject that will help shape our future.

Also, the experience of the guests that spoke helped us understand that a future in FLEET is very real.

I think it was great to see professionals and people who do what we are learning about as a living, and to also hear from their experiences, it puts everything into perspective

### **Gaining breadth, depth of physics - career (N=3)**

This is a reappearance of the theme in above question where students valued insight into depth and breadth of physics, though here it is specific to career in physics. See relevant student responses below.

Helped us value various careers in physics and let us understand what kind of work would be involved

... and to also hear from their experiences, it puts everything into perspective and broadens the range of options one might have about their future

### **[Simply interesting] (N=3)**



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Students made the reference simply that they found the FLEET presenters interesting. See relevant student responses below.

It made me realize that although quantum and FLEET was a difficult topic, it could still be made in a way that is interesting.

## Discussion – what it all means

Although there is some variance in the responses over the last three years, there is also some relative consistency. Regardless the FLEET unit continues to inspire students to consider physics as a career, and potentially of greater importance, it shifts perceptions about the value of the discipline and its role in solving real world problems.

I first distil the quantitative survey data and examine the points of difference between the 2023 and 2021-22 data. I then focus on two core themes of interest to FLEET that emerged from the combined quantitative and qualitative data: a new awareness, perspectives and appreciation of physics (and related subjects), and FLEET presenters are crucial.

### Enjoyable, interesting and valuable

Similar to 2021 and 2022, students enjoyed the FLEET unit and found it unit interesting. To varying extents, students found the topics difficult, but this did not detract from their enjoyment and interest in those topics. The majority of students agreed or partially agreed the topics were taught in an understandable way.

About 84% of students agreed or partially agreed that the FLEET unit topics should be kept in future years. In 2022, there was a relatively high proportion of students that said they didn't want the topology topic kept in the unit. In contrast, a large majority of the 2023 cohort agreed or partially agreed that it should be kept. This reflects that each cohort will differ in their interests and abilities. It could also be mean that JMSS physics teachers have adjusted how they teach this topic. The data on whether this occurred in unavailable.

This year, Quantum physics and Binary, Transistors and Boolean Logic were the most popular topics with 78% and 75% of students respectively agreeing that these two topics should be kept in future years.

Similar to the 2020-21 data, a small majority of students (56%) thought that most of what they learned in the unit was of value regardless of their intended career path.



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The following is discussion of the two core themes to emerge from the quantitative and qualitative data: a new awareness, perspectives and appreciation of physics, and FLEET presenters are crucial.

### **Greater awareness, appreciation of physics**

A core theme to emerge in the data relates to students' greater awareness and appreciation of the awareness of physics as a discipline and its roles in solving real-world problems. Although only six students specifically said their experience in the FLEET unit has made them want to go on and study physics, one of the FLEET unit's objectives is to shift student perceptions on the value of STEM and especially physics. The value of this student shift in perception and appreciation of physics is manifested in comments such as the following where this new perception suggests students now understand how physics has enabled much of the technology we interact with and is crucial to solving some of the world's problems:

It has opened my eyes to topics that I never thought of before, and changed the way I view computers, AI and their functions

It has made me value it slightly more, as it's necessary to solve the future energy crisis.

It has made me appreciate the principles and rules of physics used in places where it is hidden and around us.

### **FLEET presenters are crucial**

The theme, FLEET presenters are crucial, was a core theme in the 2022 and 2021 data. Again in 2023, students considered FLEET presenters played a valued role in helping students develop new perspectives on physics and facilitate an increased breadth and depth of understanding of the discipline of physics and the role of physicists. This year, students also perceived that FLEET researchers helped improve their understanding of the topics they were being taught.

In support of the 2020-21 findings, students noted in the survey that what they enjoyed most about the course were the experiments or practical components, lab tours and engagement with the FLEET presenters. This strongly reflects the student interview data from 2021 and 2022 that found FLEET presenters, through their engagement with students in the practical sessions and lab tours, gave students a deeper and broader understanding of the discipline of physics, and the role of a physicists. Their engagement with FLEET presenters in the practical sessions and lab tours also enabled them to see a purpose and value to physics. Students became aware of how physics is applied to solve real-world problems. FLEET presenters made physics relevant and palpable. This connection to real physicists and their role is also one of the reasons for students shifting towards a greater likelihood of studying physics or pursuing physics as a career.



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## Appendix 1. Quantitative survey data for FLEET unit 2023

Topic 1 - Conductors, Insulators and Semi-Conductors

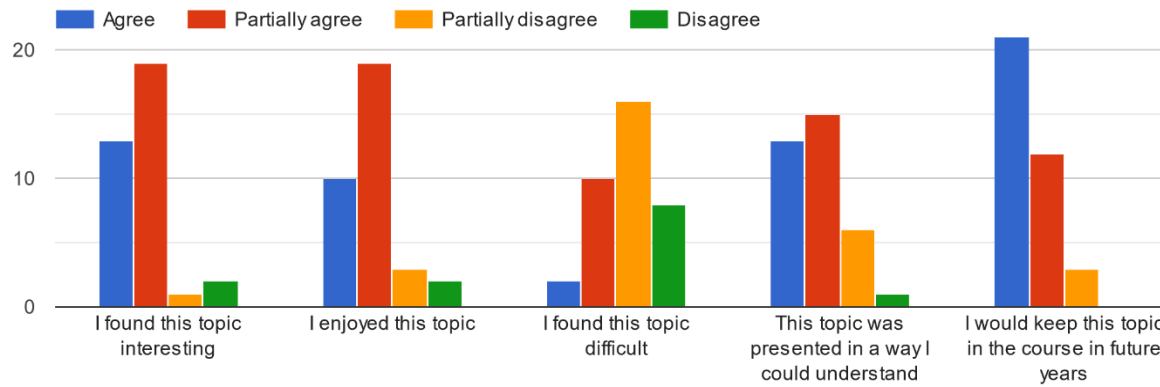


Figure 1. Survey questions for the topic, Conductors, Insulators and Semi-conductors





## Topic 2 - Binary, Transistors and Boolean Logic

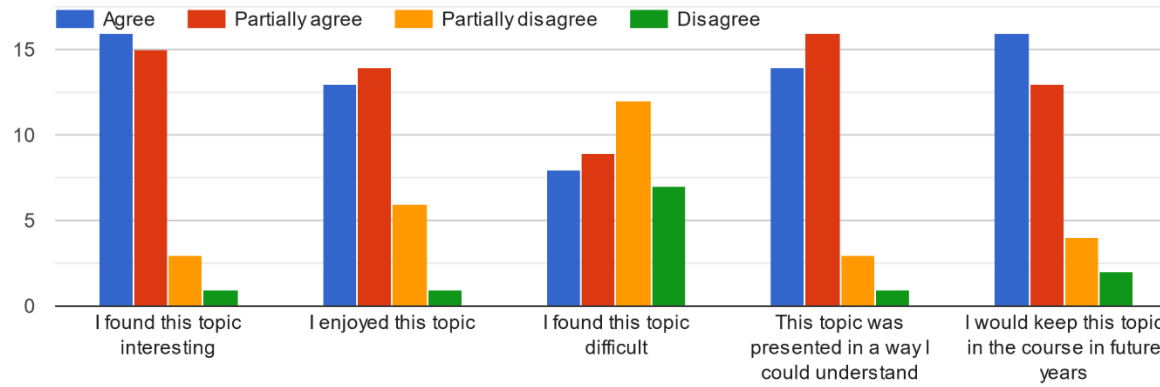


Figure 2. Survey questions for the topic, Binary, Transistors and Boolean logic



Topic 3 - Momentum and Kinetic Energy

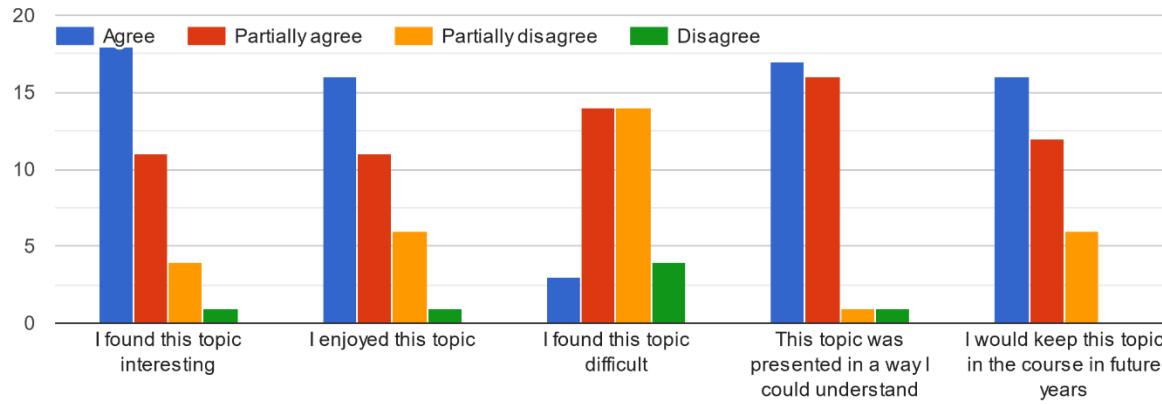


Figure 3. Survey questions for the topic, Momentum and kinetic energy



## Topic 4 - Quantum Physics

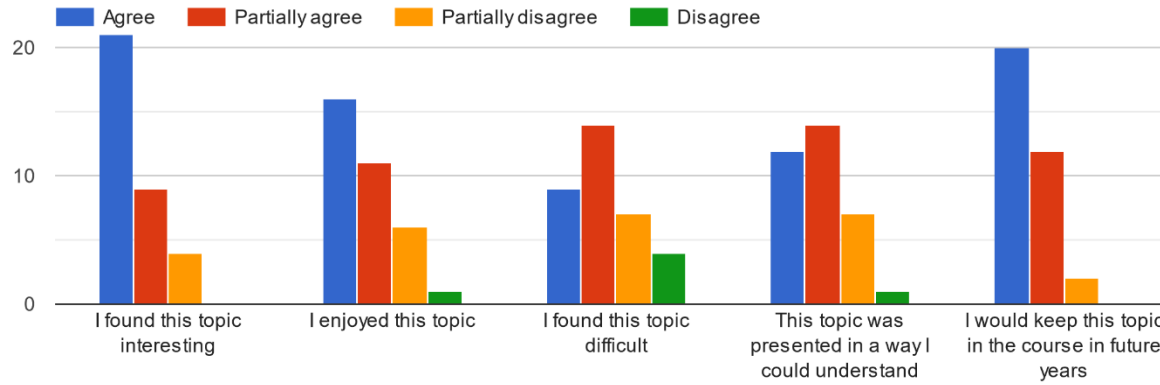


Figure 4. Survey questions for the topic, Quantum physics



## Topic 5 - Topological Materials

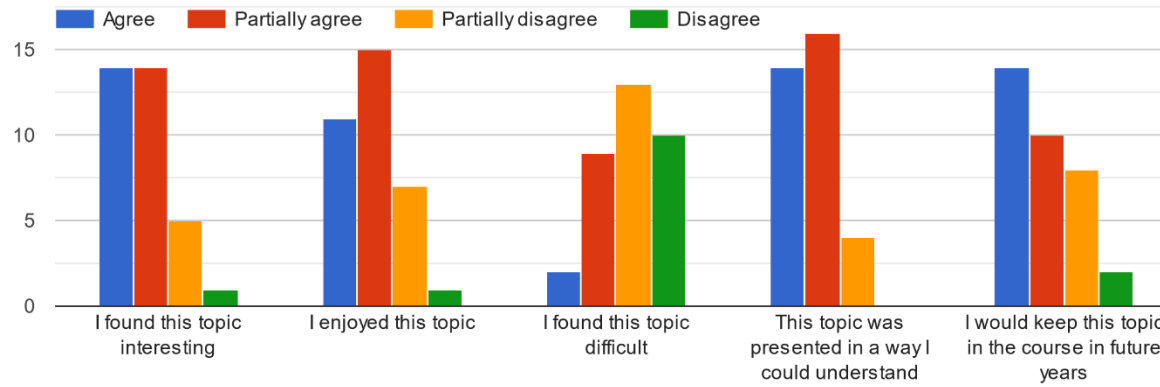


Figure 5. Survey questions for the topic, Topological materials



## Topic 6 - Superfluids and Excitons

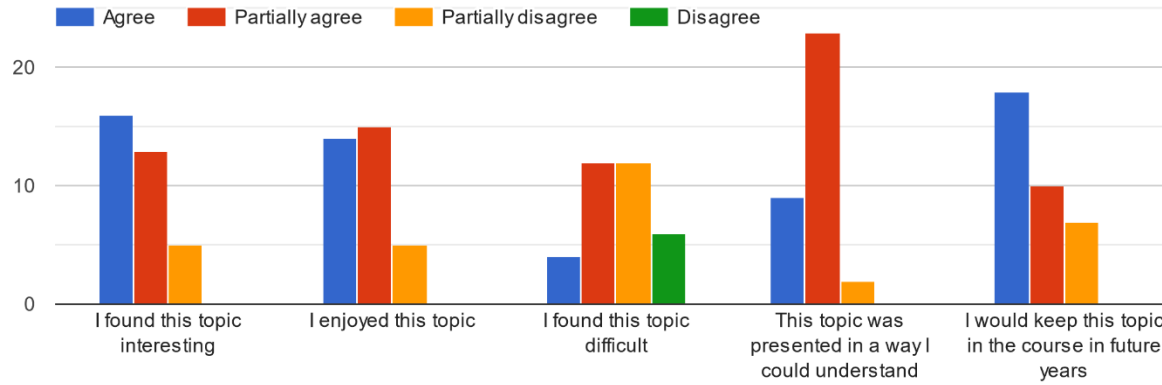


Figure 6. Survey questions for the topic, Superfluids and excitons