Personalizing, Differentiating and Engaging Through Technology

A technology inventory and plan for teaching high school physics mechanics topics through the thematic study of drones

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This paper describes the technology resources required to support the teaching of the International Baccalaureate Physics course Mechanics topics 2.1 through 2.4 (Siegel, 2022) as part of an integrated STEM project based on the physics of drones. The inventory required to deliver the series of five lessons includes the following:

- A class set of LiteBee Brix III toy drones (or similar)
- A site license for Vernier's Logger Pro 3 software
- A class set of Vernier dual-range force sensors
- Student laptops able to run Logger Pro 3, Google Suite and Desmos

If an alternative drone model is chosen, it should be rugged, suitable for use in a classroom environment, and with a minimal learning curve. It is not the intent of this project to teach students coding skills; the purpose of the drone is to demonstrate the physics principles involved and provide opportunities for hands-on experimentation. Vernier's Logger Pro 3 software runs on both Windows and Mac operating systems and does not need to be distributed to centrally managed student laptops via an IT department (although it can be); students at "bring your own device" schools can easily download and install it themselves once given the site license details. Each Vernier dual-range force sensor will require a Vernier sensor interface such as the EasyLink or LabQuest Mini. As Redman noted in 2017, the "E" component of the STEM acronym is still an often neglected and misunderstood topic among K-12 educators. It is hoped that this 5-lesson series and accompanying technology plan will help redress that balance somewhat by supporting physics educators in including engineering and design activities in their lessons.

Technology Plan

Lesson 1

Activity Description	Technology Tools and Resources	Usage Notes
Introduction Project introduction and competitor research.	• Laptops • Google Suite • Web browser	Have students create a project folder in Google Drive and share it with you. Remind them to bookmark links that they will need to visit often. Ask them to start a project research document in a shared Google document inside their project folder. Some project teams may wish to experiment with 3rd party team or project management software.
Guided Practice Order of magnitude calculations for drone motion graphs.	• Laptops • Web browser	Although the focus of this activity should be "back of the envelope" calculations (meaning students should be sketching and writing in notebooks and/or on whiteboards or walls), students should be encouraged to leverage technology, for example by looking up typical values or checking to see if a graph makes sense in Desmos.
Independent Practice Setting up slide deck and Desmos motion graph templates	• Desmos • Google Slides	Support students with restricting domain and range in Desmos. Remind students to login with their Google accounts and save each graph before starting the next one. Ask them to create a Google Slides deck inside their project folder and add one slide for each motion graph that they

		plan to present.

Lesson 2

Activity Description	Technology Tools and Resources	Usage Notes
Introduction Drone movement familiarisation and acceleration estimate.	• LiteBee Brix III • Laptops • Web browser	Have one pre-assembled toy drone ready for groups who are struggling to get theirs working "out of the box". Encourage students to check their acceleration estimates by searching for examples online.
Guided Practice Thrust and clamping force estimates.	• Laptops • Web browser	Although the focus of this activity should again be "back of the envelope" calculations (see Lesson 1 notes), students should be encouraged to leverage technology, for example by looking up typical values of (for example) coefficient of friction. Remind students to compile results in their shared project research document.
Independent Practice Measuring drone forces and accelerations experimentally.	• Vernier force sensor • Logger Pro software • LiteBee Brix III	Ensure that a variety of "maker space" type materials are on hand so that students can devise ways of connecting the drones and the force sensors. Encourage students to refer to the force sensor user manual to troubleshoot problems rather than relying on you to get them "unstuck".

Lesson 3

Activity Description	Technology Tools and Resources	Usage Notes
Introduction Battery energy density problem discussion.	● Laptops ● Web browser	Ask students to summarise any points relevant to the design and/or operation of drones in their shared project research document.
Guided Practice Power and energy requirements calculations; battery and shock spring sizing calculations.	● Laptops ● Web browser	Although the focus of this activity should again be "back of the envelope" calculations (see Lesson 1 notes), students should be encouraged to leverage technology, for example by looking up typical values of (for example) spring sizes or efficiency. Remind students to compile results in their shared project research document.
Independent Practice Adding new work from Lessons 2 and 3 to Google slide decks.	● Desmos ● Google Slides	Project teams should continue to add to their Google Slides decks from Lesson 1. New slides should just summarise key results of new calculations; the details can be saved in their shared project documents. Remind teams that they should go back and update their Desmos motion graphs based on recent calculations.

Lesson 4

Activity Description	Technology Tools and Resources	Usage Notes
Introduction Tyranny of the rocket equation discussion.	● Laptops ● Web browser	Ask students to summarise any points relevant to the design and/or operation of drones in their shared project research document.
Guided Practice Rotor air flow and payload ejection mechanism calculations.	● Laptops ● Web browser	Although the focus of this activity should again be "back of the envelope" calculations (see Lesson 1 notes), students should be encouraged to leverage technology, for example by looking up typical values of (for example) rotor diameter or air density. Remind students to compile results in their shared project research document.
Independent Practice Further experimental work - either refining previous experiments or investigating new variables.	● Vernier force sensor ● Logger Pro software ● LiteBee Brix III	Ensure that a variety of "maker space" type materials are on hand so that students can devise ways of (for example) connecting the drones and the force sensors, or adding mass to the drones to simulate flights with payload. At this point, assist struggling groups with the use of force sensors and/or video tracking features so that they have some results to add to their presentations.

Lesson 5

Activity Description	Technology Tools and Resources	Usage Notes
Introduction First principles thinking discussion.	• Laptops • Web browser	Ask students to summarise any points relevant to the design and/or operation of drones in their shared project research document.
Guided Practice Scaling up calculations from Lessons 1-4 for each project team's chosen application.	• Laptops • Web browser • Desmos • Google Slides	Project teams should update their Google slide decks, shared research documents and Desmos graphs with new values as they go.
Independent Practice Iteratively refining design calculations and slide decks in preparation for a hypothetical seed funding event.	• Laptops • Web browser • Desmos • Google Slides • Logger Pro software	Assist groups in ensuring that their slide decks are "event appropriate". Point them towards the Google Slides "Explore" feature and remind them to use summary tables for calculation results rather than sentences. Encourage them to include graphs of experimental results in their presentations to improve credibility.

Conclusion

By explicitly connecting high school physics topics with an engineering and design context, we can increase the appeal of STEM learning to a more diverse range of students, catering to those who prefer hands-on, experiential learning to the traditional analytical approach. Moreover, by situating the learning in an authentic project management context, we naturally integrate the 5 Key Elements of Differentiation as described in McGee (2017). Personalization also occurs naturally as student teams choose a unique drone application that they are interested in researching and designing. Finally, we can view the teaching of physics through drones, a technology that has only become widely available relatively recently, as an example of the "R" (Reimagine) in Puentedura's SAMR Model (2015). By using drones to support the teaching of physics concepts in ways that were previously not possible, we can "reimagine" the way that Newtonian mechanics is taught and unlock new methods (and higher levels) of differentiation, personalization and engagement.

References

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