**Explore Problem Planning Template**

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| **Unit Title:** | **Lesson #: Momentum 4, calculating gravitational acceleration with f=ma** |
| **Daily Objective:**  | Be able to calculate acceleration from gravity as 10m/s2 (9.8) and explain that this acceleration applies to all objects on earth regardless of mass or state of motion |
| **Key Understanding** | *What is the perfect articulation of the concept you’re working on today?*KP1: acceleration can be calculated as a=F/mKP2: on Earth, every object’s gravitational force and mass will always equate to 9.8m/s2 regardless of mass or state of motion |
| **Framing** | *How will you introduce the problem to the class?*We can calculate an object’s mass using a balance, and we can calculate an object’s gravitational force using a spring scale. Can you use this information to verify or disprove what we have read that gravitational acceleration is 9.8m/s2?*What are the assumptions, information, or constraints you want to highlight?*We are making the assumption based on our observations from 2nd quarter about how objects interact, that the formula F=ma is usable to determine an object’s forceWe are making the assumption that even though gravity does not work by means of a physical touch, it still follows the same rules as every other forceWe are making the assumption that Newton’s 3rd Law of motion states that every force has an equal and opposite force (this has already been taught)*What is the end goal?*Students will articulate that all objects have a calculated acceleration of 9.8~10m/s2 because they are all being pulled to Earth by gravity.*What direction will you give students for work time?*Use the materials you have been provided to collect the force and mass of 5 objects then calculate their accelerations in a table. |
| **Using Correct Student Work to Drive Discussion** | Correct Student Work* Give 2 – 3 examples of correct methods students may use to solve this problem that you will highlight during Show Call
* Below each example, list potential questions you could ask to foster discussion
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| Correct Sample Work 1:  |
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| --- | --- | --- | --- |
| Object | Force | Mass | Acc |
| Can | 4.8 N |  .5 kg | 9.6m/s2 |
| Ruler | .6 N |  .06 kg | 10m/s2 |
| Iron Block | 2.4N |  2.5 kg | 9.6m/s2 |

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| Question to begin discussion of work: |
| What do you notice about these accelerations? |
| Anticipated Answer 1 | Anticipated Answer 2 | Anticipated Answer 3 |
| They stay right around 9.8 or 10 each time | They decrease then increase |  |
| Follow-up Question | Follow-up Question | Follow-up Question |
| What does this number 10 represent, as we do f/m | Does this decrease and increase seem significant or within the scope of experimental error (we have not yet established a parameter for error ie % error, but I will include an overview of how to read/calibrate the spring scales with questions asking how accurate we should call our measurements)  |  |
| **Using Correct Student Work to Drive Discussion (Continued…)** | Sample Work 2 |
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|  |  |  |  |
| --- | --- | --- | --- |
| Object | Force | Mass | Acc |
| Can | 4.8 N |  .5 kg | 9.6m/s2 |
| Ruler | .5 N |  .06 kg | 8.3m/s2 |
| Marker | .8N | .1 kg | 8.0m/s2 |

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| Question to Begin Discussion of Work |
| What do you notice about these accelerations? |
| Anticipated Answer 1 | Anticipated Answer 2 | Anticipated Answer 3 |
| They are decreasing each time | The lighter objects seem to be farther away from 10m/s2  |  |
| Follow-up Question | Follow-up Question | Follow-up Question |
| Do the object’s masses decrease/increase each time as this happens? (I don’t see this as leading. When they see that the masses do not actually go in order, they should infer that there is no correlation between mass and the supposedly decreasing acceleration) Can you explain why you think this decrease is happening? | Why do you think lighter objects would have less accurate results, if we were expecting 9.8/10m/s |  |
| **Using Student Errors to Drive Discussion** | Anticipated Student Errors* List 2 – 3 potential errors students could make while working to solve this problem. Keep in mind that student errors should lead students to the key understanding
* Below each example, list questions you could ask to help push their understanding
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| Ex 1Measuring wrong especially on light objects | Ex 2Incorrectly applying the formula to get the acc | Ex 3Not connecting their calculated accelerations to gravitational acceleration of 9.8m/s2 |
| Questions:I’m questioning some of the data points you collected; can you show me how you got that? (may be due to miscalibrated spring scales or reading the marks on the spring scales as .1, not .2) | Questions:If we know the formula F=ma, what is the operation we should do to find acceleration? | Questions:Why is it significant that all of these objects calculate an acceleration of just about 10m/s2.  |
| **Stamp the Key Understanding** | How will you have students stamp the key understanding once it has been articulated?**Every object has the same gravitational acceleration- 9.8m/s2****Given an object’s gravitational force, we can also find its mass** |
| **Apply the Key Understanding** | What 1-2 questions will you ask or have students solve to quickly apply the key understanding and check for understanding?State the expected gravitational acceleration of a 2.8kg brick.If a wood block has a force of 1.3N, give an approximate mass of the block(I am okay with including a separate question on weight transferable to another planet, but my objective is that students “calculate acceleration from gravity as 10m/s2 (9.8) and explain that this acceleration applies to all objects on earth regardless of mass or state of motion” so I really do want to keep the focus centralized to Earth. This was a major misconception on the exam which is in large part why I want to review it) |