Lesson on Force

This lesson package includes a lesson plan, classwork/homework assignments, and a rubric and answers for the homework.

Activity	**5E**– Engage, Explore, Explain, Elaborate, Evaluate **PRO** – Principles, Reasoning, Outcome	**Modes of representation**
Lesson 1 (60 min) Task 1– Prediction activity before the demonstration (refer to Classwork 1)	Engage students in predicting what would happen in given scenarios – what they think they would observe (O) and why they think this would be the case (attempting P & R) through Think, Pair, Write, Share	Verbal (if discussion is encouraged) Written
Live demonstration of the scenarios Equipment needed: 2 skateboards with 2 safety helmets; spring balances for pairs of students	Students explore the scenario through hands-on (with the spring balances) or through watching/experience live demo	Visual (e.g readings on spring balances) Physical
Task 2 – Individually, students draw what they have observed and explain their observation (refer to Classwork 1)	Students draw what they observed (O) and provide an explanation (attempting P & R)	Visual (diagram) Written
Task 3- In groups, students compare their written explanations, guided by the textbook and the teacher	Textbook/teacher provides the necessary vocabulary and concepts to help students refine their explanation	Verbal Visual (textbook)
Class discussion	Teacher introduces Newton's Third Law of Motion and corrects all layman terms (push, pull, faster/slower) to scientific terms (action, reaction, higher/lower acceleration)	Verbal Visual (if terms are written on the whiteboard)
Task 4- Individually, students attempt to refine their diagram and	Students refine their diagrams (O) and explanations (P & R)	Visual Written

Source: Project OER 48/12 TKS funded by the Education Research Funding Programme, National Institute of Education (NIE), Nanyang Technological University, Singapore. Adapted by Knowledge Mobilisation Unit, Office of Education Research, NIE, 2018.

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their explanation (third column in Classwork 1)		
Lesson 2 (60 mins) Task 1– Prediction activity before the demonstration (refer to Classwork 2) Live demonstration of the scenarios Equipment needed: 2 skateboards with 2 safety helmets Task 2 – Individually, students draw what they have observed and explain their observation (refer to Classwork 2), Task 3- In groups, students compare their written explanations, guided by the textbook and the teacher Class discussion Task 4 - Instruct students to circle the correct "faster / slower" phenomena (Question 2 in Classwork 2) Students fill in the blanks of sentences as teacher is explaining	Engage students in predicting what would happen in given scenarios – what they think they would observe (O) and why they think this would be the case (attempting P & R) through Think, Pair, Write, Share Students explore the scenario through watching/experience live demo Students draw what they observed (O) and provide explanation (attempting P & R) Textbook/teacher provides the necessary vocabulary and concepts to help students refine their explanation Teacher introduces Newton's Second Law of Motion and correct all layman terms (heavy, light) to scientific terms (higher mass, lower mass) Use teacher modelling to get students to notice how mass and force affect acceleration (P). Students refine their observation (O)	Verbal (if discussion is encouraged) Written Visual (watching the demo) Physical (for those in the live demo) Visual (diagram) Written based on diagram Verbal Visual (textbook) Verbal Visual (if terms are put on the whiteboard) Verbal Visual (circling, filling in blanks) Written Written

Activity	**5E**– Engage, Explore, Explain, Elaborate, Evaluate **PRO** – Principles, Reasoning, Outcome	**Modes of representation**
(Question 3). Students deduce the formula (F=ma) and identify the proportional relationship among the factors Task 5- students apply their understanding to given scenarios Task 6- Students should then refine their explanations using Newton's Third Law, Second Law, and the scientific terms with the aid of appropriate diagram in the last column Task 7 Task 7- as a class, students and teacher jointly craft the PRO for question 1 (refer to homework) Homework: Students to build their explanations of the scenarios with the PRO structure as a scaffold.	Students indicate the key principles (P) in Newton's Second Law of Motion Practise problems involving mathematical formula Students refine their explanation (P & R) using both words and diagram Teacher explicitly introduces the PRO structure to students before continuing to Task 7. Teacher should go through at least 1 question in class Students to craft explanations using the PRO structure	Written Written Visual (diagram) Written Visual (given diagrams)
Lesson 3 (60 min) Task 1- Students to assess their peers' answers according to given rubric/instructions. Task 2- Students to attempt selected questions from the workbook	 Students evaluate conceptual understanding through peer assessment Students to write explanations without the PRO scaffold	 Written Visual (checklist) Written

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Classwork 1

Lesson 1

Complete the table below

	Pre-Demonstration/Activity Questions	
Demonstrations/ Activities	What do you predict will happen?	What makes you think so?
Scenario 1a Two skaters were pushing against each other		
Scenario 1b A skater was pushing the other skater from behind		
Scenario 2 A pair of connected spring balances was pulled at one end.		
Scenario 3 A skater was pushing against the wall.		

	Post-Demonstration/Activity Questions		
Demonstrations/ Activities	Draw a labelled diagram to illustrate your observation.	Using your diagram, explain your observation.	Refine/revise/correct your explanation, including a refined diagram.
Scenario 1a Two skaters were pushing against each other			
Scenario 1b A skater was pushing the other skater from behind			
Scenario 2 A pair of connected spring balances was pulled at one end.			
Scenario 3 A skater was pushing against the wall.			

Classwork 2

Lesson 2

1. Complete the table below

	Pre-Demonstration/Activity Questions	
Demonstrations/ Activities	What do you predict will happen?	What makes you think so?
Scenario 1a A student pushes a lighter skater		*This could include sources of their experiences or their own explanations*
Scenario 1b A student pushes a heavier skater		
Scenario 2a A skater pushes against the wall with less effort.		
Scenario 2b A skater pushes against the wall with more effort.		

	Post-Demonstration/Activity Questions		
Demonstrations/ Activities	Draw a labelled diagram to illustrate your observation.	Using your diagram, explain your observation.	Refine/revise/correct your explanation, including a refined diagram.
<u>Scenario 1a</u> A student pushes a lighter skater	*This could include arrows that represent motions (may not be force) or just skaters that are moving.*		
<u>Scenario 1b</u> A student pushes a heavier skater			
<u>Scenario 2a</u> A skater pushes against the wall with less effort.			
<u>Scenario 2b</u> A skater pushes against the wall with more effort.			

2. Compare the ‘a’ and ‘b’ parts of both scenarios demonstrated. Circle the correct motion (Faster / Slower) of each skater.

	‘a’	‘b’
Scenario 1 - A student pushes a lighter skater and a heavier skater	Scenario 1a Similar force Lower mass skater (Faster / Slower)	Scenario 1b Similar force Higher mass skater (Faster / Slower)
Scenario 2 - A skater pushes against the wall with less effort and more effort	Scenario 2a Same mass Lower force (Faster / Slower)	Scenario 2b Same mass Higher force (Faster / Slower)

3. Select one word/phrase from each column A to K to construct a proper sentence. Then, re-write your sentences in the given table.

A	B	C	D	E	F	G	H	I	J	K
From scenario 1a and 1b,	if	*force *acceleration *mass	*remains *continues *persists	*the same *constant *fixed	,	*acceleration *force	is	*directly *inversely *linearly	proportional to	*force *mass
From scenario 2a and 2b,	if	*force *acceleration *mass	*remains *continues *persists	*the same *constant *fixed	,	*acceleration *mass	is	*directly *inversely *linearly	proportional to	*force *mass

From scenario 1a and 1b,	Mathematical relationship: ________________ is ______________ proportional to ___________
From scenario 2a and 2b,	Mathematical relationship: ________________ is ______________ proportional to ___________
Combining both scenarios,	The formula is_______________

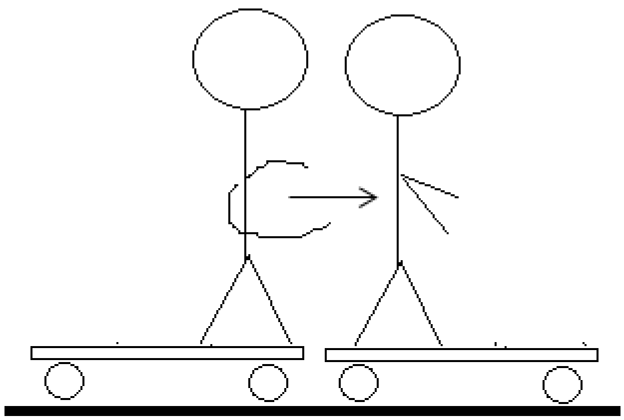
4. A student pushes a skater of mass 50 kg with a force of 25 N. Calculate the acceleration of the skater.

5. A skater of mass 60 kg pushes the wall with a force of x N and moves away from the wall with an acceleration of 2 ms^{-2}. Calculate x.

Homework

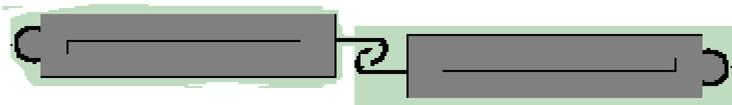
Lesson 1

1. In Scenario 1b from Lesson 1, why did both skaters move away from each other when only a skater was pushing?



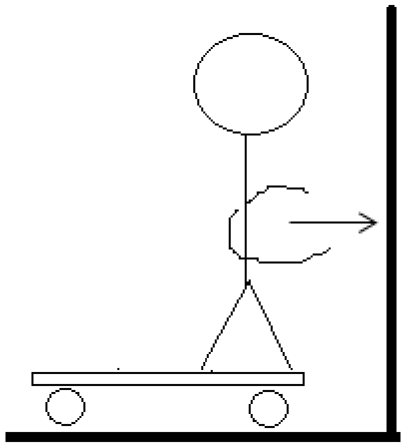
Principles *(What do you know? What laws/principles are involved ? What's the underlying concept?)*	When the skater was pushing, ______________________________ ____ According to Newton's ______________, a ________________ force ____ ____________________________________
Reasoning *(What follows from the principles?)*	Therefore, ____ ____
Outcome *(What is your conclusion?)*	Thus, ____ ____

2. In Scenario 2 from Lesson 1, why did the spring balances show similar readings?



Principles *(What do you know? What laws/principles are involved? What's the underlying concept?)*	When one of the spring balances was _________, a force ________ ____ According to Newton's ______________, a ________________ force ____ ____________________________________
Reasoning *(What follows from the principles?)*	Therefore, ____ ____
Outcome *(What is your conclusion?)*	Thus, ____ ____

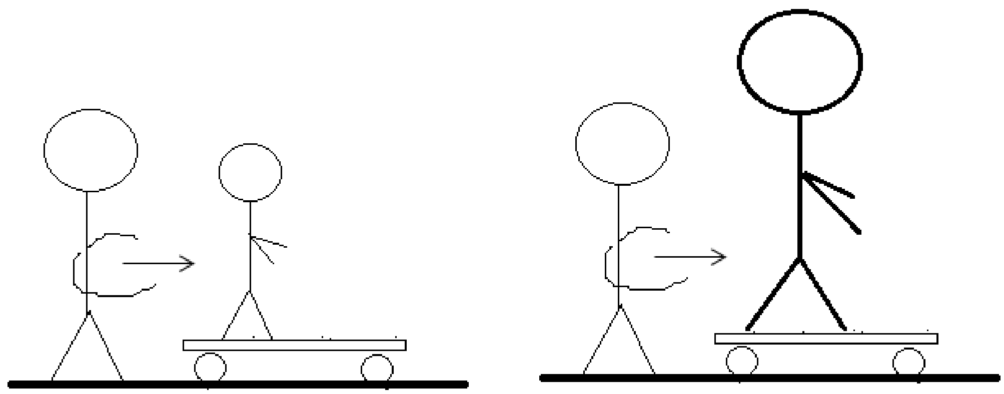
3. In Scenario 3 from Lesson 1, why did the student move away from the wall?



Principles *(What do you know? What laws/principles are involved? What's the underlying concept?)*	When the skater was pushing _______________, a force ________ ____
	According to Newton's ______________, a ________________ force ____ ____________________________________
Reasoning *(What follows from the principles?)*	Therefore, ____ ____
Outcome *(What is your conclusion?)*	Thus, ____ ____

Lesson 2

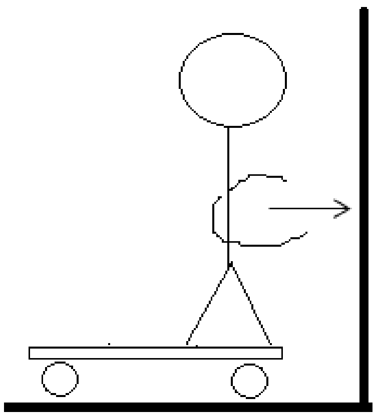
4. Compare Scenario 1a (lower mass) and 1b (higher mass) from Lesson 2: Why did the lighter skater move faster than the heavier skater?



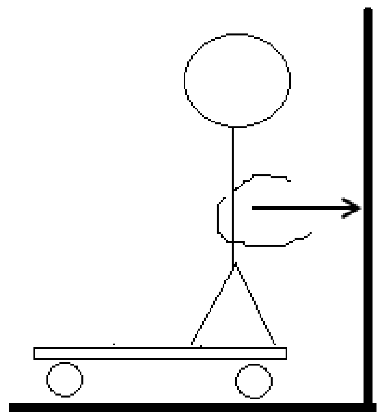
1a 1b

Principles *(What do you know? What laws/principles are involved? What's the underlying concept?)*	In Scenario 1a and 1b, similar forces were ____________________ ____
	According to Newton's ______________, when force__________ ___________, mass ______________________________________ ______________________________________
Reasoning *(What follows from the principles?)*	Therefore, when the forces exerted on both skaters ____________, mass ____ ____
Outcome *(What is your conclusion?)*	Thus, ____ ____

5. Compare Scenario 2a (lower force) and 2b (higher force) from Lesson 2: Why did the skater move faster when he pushes against the wall with heavier effort?



2a



2b

Principles *(What do you know? What laws/principles are involved? What's the underlying concept d?)*	When the skater was____, according to Newton's ______________________________________ ____
	At the same time, according to Newton's _____________________, when mass ____________________, force _____________________ ____
Reasoning *(What follows from the principles?)*	Therefore, when the skater has the same __________, ___________ ____ ____
Outcome *(What is your conclusion?)*	Thus, ____ ____

Homework Rubric for Peer Check

Lesson 1

In Scenario 1b, why did both skaters move away from each other when only a skater was pushing?

Criteria	(Yes) √
- Force is exerted on the other skater	
- *Newton's Third Law	
- Reaction force **with the same magnitude** will be reflected to the skater who pushes	
- The skater who pushes moves away	
- Thus, both skaters move away when only a skater was pushing *(conclude answer to the question)*	

*No tick if Newton's Third Law alone was mentioned/defined without applying it to the question/situation.

In Scenario 2, why did the spring balances show similar readings?

Criteria	(Yes) √
- Force is exerted on the other spring balance	
- *Newton's Third Law	
- Reaction force **with the same magnitude** will be reflected on the pulled spring balance	
- Pulled spring balance shown reading	
- Thus, both spring balances show similar readings *(conclude answer to the question)*	

*No tick if Newton's Third Law alone was mentioned/defined without applying it to the question/situation.

In Scenario 3, why did the skater move away from the wall?

Criteria	(Yes) √
- Force exerted on the wall	
- *Newton's Third Law	
- Reaction force **with the same magnitude** will be reflected on the skater	
- Skater moves	
- Thus, the skater moved away from the wall *(conclude answer to the question)*	

*No tick if Newton's Third Law alone was mentioned/defined without applying it to the question/situation.

Lesson 2

Compare Scenario 1a and 1b, why did the light weight skater move faster than the heavy weight skater?

Criteria	(Yes) √
- Similar forces were exerted on both skaters	
- *Newton's Second Law	
- When force remains constant, mass of the object is inversely proportional to its acceleration. *(define Newton's Second Law according to given situation)*	
- When the forces exerted on both skaters are similar, skater with higher mass would travel with lower acceleration. *(apply Newton's Second Law to the situation)*	
- Thus, the lighter skater moves faster than the heavier skater *(conclude answer to the question)*	

*No tick if Newton's Second Law mentioned has no direct relevance to the question/situation. (E.g. *when mass remains constant/ F = ma …etc.*)

Compare Scenario 2a and 2b, why did the skater move faster when he pushes against the wall with heavier effort?

Criteria	(Yes) √
- *Newton's Third Law	
- a reaction force **with the same magnitude** is reflected on the skater	
- **Newton's Second Law	
- When mass remains constant, force exerted on the object is directly proportional to its acceleration *(define Newton's Second Law according to given situation)*	
- When the skater has the same mass, higher force exerted on the wall would results in higher acceleration. *(apply Newton's Second Law to the situation)*	
- Thus, the skater moves faster when he pushes against the wall with heavier effort. *(conclude answer to the question)*	

* No tick if Newton's Third Law alone was mentioned/defined without applying it to the question/situation

**No tick if Newton's Second Law mentioned has no direct relevance to the question/situation. (E.g. *when force remains constant/ F = ma …etc.*)

Homework Answers

Lesson 1

In Scenario 1b, why did both skaters move away from each other when only a skater was pushing?

When the skater was pushing the other skater, a force is exerted on the other skater. According to Newton's Third Law of Motion, a reaction force with the same magnitude will be reflected on the skater who pushed. Therefore, the skater who pushes, moves backwards. Thus, both skaters move away from each other when only a skater was pushing.

In Scenario 2, why did the spring balances show similar readings?

When one of the spring balances was pulled, a force is exerted on the other spring balance. According to Newton's Third Law of Motion, a reaction force with the same magnitude will be reflected on the pulled spring balance. Therefore, the pulled spring balance showed a similar reading to the other spring balance. Thus, both spring balances show similar readings.

In Scenario 3, why did the skater move away from the wall?

When the skater was pushing against the wall, a force is exerted on the wall. According to Newton's Third Law of Motion, a reaction force with the same magnitude will be reflected on the skater. Therefore, the skater moves in the direction of reaction force. Thus, the skater moved away from the wall.

Lesson 2

Compare Scenario 1a and 1b: Why did the lighter skater move faster than the heavier skater?

In Scenario 1a and 1b, similar forces were exerted on both skaters. According to Newton's Second Law, when force remains constant, mass of the object is inversely proportional to its acceleration. Therefore, when the forces exerted on both skaters are similar, skater with higher mass would travel with lower acceleration. Thus, the lighter skater moves faster than the heavier skater.

Compare Scenario 2a and 2b: Why did the skater move faster when he pushes against the wall with heavier effort?

When the skater was pushing against the wall, according to Newton's Third Law, a reaction force with the same magnitude is reflected on the skater. At the same time, according to

Newton's Second Law, when mass remains constant, force exerted on the object is directly proportional to its acceleration. Therefore, when the skater has the same mass, higher force exerted on the wall results in higher acceleration. Thus, the skater moves faster when he pushes against the wall with heavier effort.