COURSE TITLE

Problem Title	How to win a tug of war competition

Author	Eddie Bradley
Email	eddie.bradley@sunderland.ac.uk

Learning Outcome(s)	
1	Define Newton's Laws of Motion
2	Describe how Newton's Laws of Motion apply to human movement
3	Demonstrate how the outcome of a tug of war can be improved through the application of Newton's Laws

Concepts / Competencies expected to engage with	• Newton's Laws of Motion

Course Level	Undergraduate introductory

This problem involves data analysis	Yes	No X	Maybe

Approximate Length	40 mins

Class/ Group Size	30 students; 3 to 4 per group

Useful References	• Hamill J, Knudsen KM. (2014). Biomechanical Basis of Human Movement (4th Ed.). London: LWW. Pg 346-354 and 363-370 • Grimshaw, P., Lees, A., Fowler, N. and Burden, A. (2019) Instant Notes: Sport and Exercise Biomechanics (2nd Ed.). London: Taylor and Francis. Pg 59-80 • Li, X. (2015). The origin, development and winning skills of Tug of War. The Open Cybernetics and Systemics Journal, 9, 2021-2024. • Nakagawa, M et al. (2005). Characteristics of pulling movements for Japanese elite tug of war athletes. ISBS Conference Proceedings, Beijing, China.

Mode of Instruction	Synchronous (Face to face) or Asynchronous (Online)

The Scenario:

You are approached by the University Tug of War team who wants to improve their chances of winning the next competition. The coach knows that you are studying biomechanics and has asked you to advise the team on how they can achieve a positive outcome for the team through the application of mechanical factors and how they can produce a successful pull (Fig. 1). The coach informs you of the rules of the competition that a) opposing teams will be of approximately equal mass; b) each team member will wear similar footwear; c) the mass of the rope is negligible; and d) you must pull the rope so the flag moves a distance of 5 m. As a student, you need to consider the various forces occurring during a tug of war and identify that through manipulating the factors associated with Newton's Laws of Motion you can help the team performance.

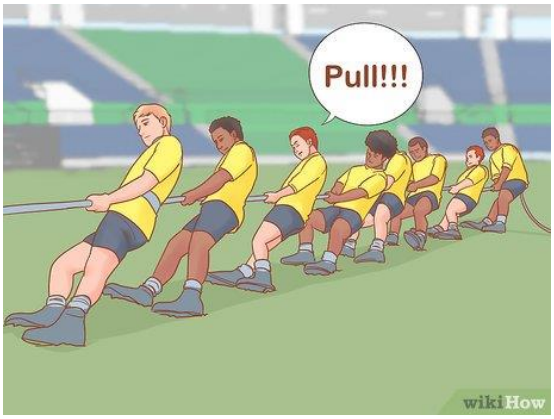

Fig.1: The act of pulling during a tug of war.

The Questions:

Make sure to include the correct biomechanics language to describe your solution correctly.

1. You ask the team to perform a tug of war between two members of the team and notice that neither athlete moves when they pull on the rope. From your understanding of Newton's Laws of Motion, why is this occurring? What is preventing either member of the team from winning the contest?
2. The coach asks you how he can change the scenario in the tug of war in question 1 to create movement. From your understanding of Newton's Laws of Motion, how would you change the circumstances in the tug of war to secure a winning outcome? What elements of Newton's Laws of Motion are you manipulating when you change the circumstances?
3. The coach asks you to explain to the team how the forces that occur during the tug of war influence the outcome of the competition. Can you draw a diagram that displays the various forces that apply that can be understood by the athletes?

Expected Outcomes:

This activity is designed to be completed in person or synchronously online. Students should be split into groups or 3 or 4 to work on the problem. After being presented with the problem, each group should discuss and produce a solution to each question in written format, which would form part of an in-class assessment. Each group should be able to orally present their solution to the rest of the class and are permitted the use of a whiteboard or flipchart to diagrammatically represent the forces occurring in each scenario. If completed in person, students may demonstrate the outcome of each scenario if a rope is available. Students in other groups may provide feedforward to the presenting group to develop their solution. Students should be able to demonstrate an understanding of the concepts of Newton's Laws of Motion qualitatively, and the impact of altering variables relating to mass and force

Guided Questions (Hints):

1. What are the masses of each tug of war athlete? Are these equal between the teams?

2. How does mass affect the inertia of an object?
3. Which law of motion relates to inertia?
4. To produce movement, what needs to be applied to an object? Which law of motion is this?
5. What is the difference between instantaneous force application and the average application over time?
6. To maximise the application of a force, what direction should this be applied in?
7. What other forces are involved in the tug of war? Consider the interaction between the athlete and the environment. What law of motion is this?