Group Work Tests

By Chris Meyer

What We're Doing

During the first fifteen minutes of a test, students will work in their regular three-person groups. They are given a version of the test question with all the important quantities necessary for calculations removed. Within their groups they discuss the problem and talk through a general plan for its solution. After the discussion phase, students work individually on the full test question which presents the same problem with the important numbers included. The students work through a detailed problem solving process as they prepare their solution.

Why

A major goal of our physics program is helping students develop expert-like problem solving skills. This is a large part of the much vaunted Higher Order Thinking Skills (HOTS!). To accomplish this, we de-emphasize straightforward, knowledge-based or algorithmic test questions in grade 12. We train students in a process to help them tackle **context-rich** problems. These problems read more like a story and often lack a precisely defined question, much like real world problems.

Challenges

Assessing these skills using a traditional test is very difficult for a number of reasons: (1) It is very time consuming, (2) Unpacking the problem is challenging, (3) Weaker students have difficulty getting started. (4) If you don't "get it", there are fewer other questions with which to demonstrate your understanding,

Our Solution

Our solution to the time challenge is to have one single question as the entire test. Students don't have to rush back-and-forth between a number of problems. They can direct their full attention to their main task. This should offer a fairly generous amount of time for its solution. Students don't progress through a challenging problem at a uniform pace. There are stops and starts, detours and dead-ends. With one question, they should have enough time to recover from any blind alleys and to go over their work carefully. This should help to reduce time pressure during the test.

Context rich problems involve many higher order thinking skills, like deciding which information is relevant, constructing a precise question to answer, planning the steps through a solution and evaluating the final results. Our students have been trained in these skills and have been regularly rehearsing them through in class challenges. This has been done through group work in class and we continue this through the starting phase of our test. The familiarity of the process should help reduce test anxiety. This also creates a more authentic form of assessment: in their future careers, engineers and scientists never work in isolation. It is in fact a crucial skill to learn to confer with colleagues before investing time and energy in a solving problem. Reinforcing the opposite behaviour through our educational practices is counter-productive.

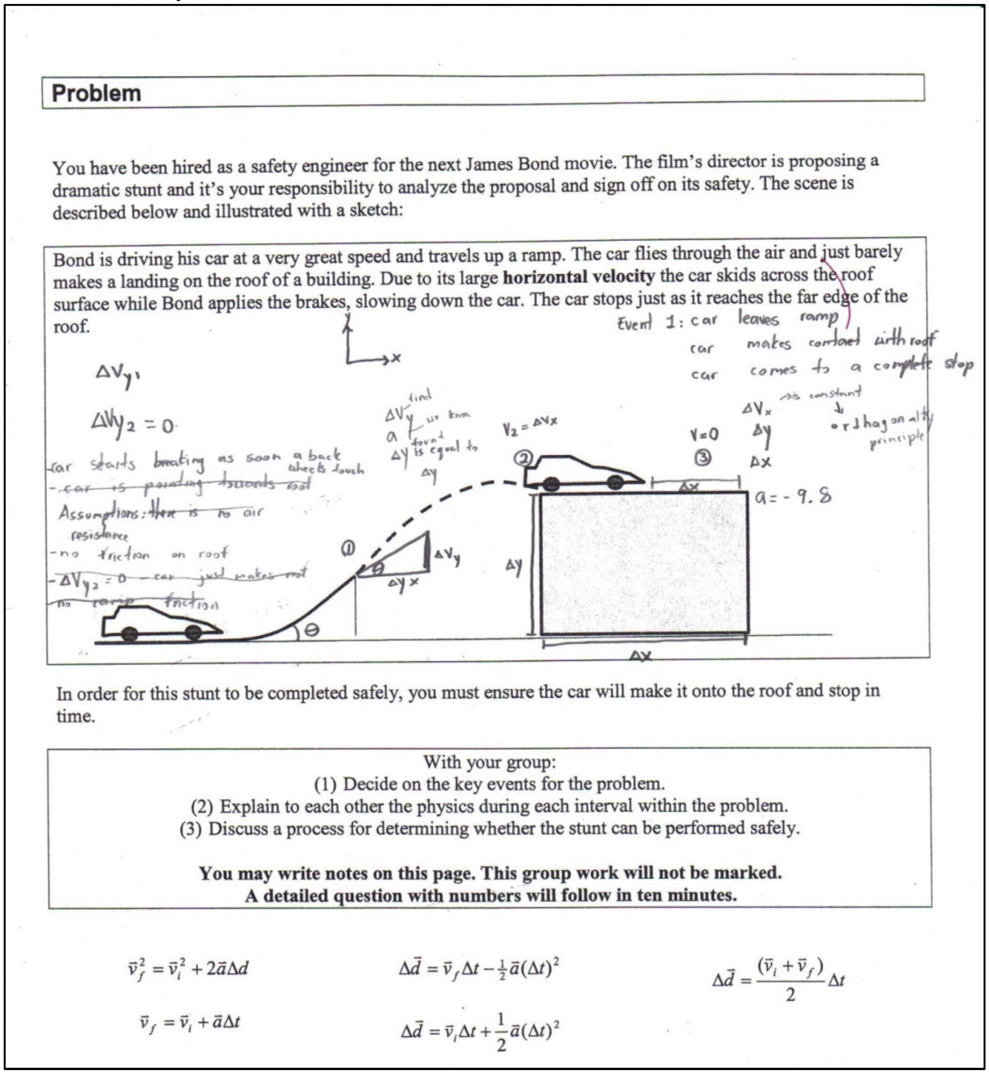
The discussion phase allows an important opportunity for students with weak language or problem solving skills to confer, ask questions and start to define the problem in their own minds. Students are allowed to keep the original problem statement the groups were given and may refer to any notes they have written. This gives them the best chance of getting started into the problem. This should also help reduce the stress level of the test. At the same time, the individual portion of the test (about 55 minutes) still provides a reliable assessment of their general physics abilities and understanding.

Even though there is only one question to solve, students use a five part solution process that helps them describe and understand the problem from multiple perspectives using pictures, technical diagrams, word descriptions, and mathematics. They have been trained in this process since grade 11, making it very familiar to them. Even if they can't find a solution to the problem, a large portion of the marks comes from the non-mathematical steps. In this way they can demonstrate their understanding of aspects of the problem using a wide variety of tools. Even if after all this they still "don't get it", there is lots for them to do on the test.

In a more recent test, we used this strategy with a set of multiple choice questions. Students were given three situations on their group discussion paper. Two of the situations would serve as the basis for a series of multiple choice questions, while the third situation would be the full answer written question. An example of this is shown at the end.

In Action!
Below are photos of the students in action. You can see an example of a median test and a lower-quartile test. Note that both of them show a high level of completion, even where the student gets "stuck". There is also an example of the group work page with a student's notes.

Here is what they started with:



Problem

You have been hired as a safety engineer for the next James Bond movie. The film's director is proposing a dramatic stunt and it's your responsibility to analyze the proposal and sign off on its safety. The scene is described below and illustrated with a sketch:

Bond is driving his car at a very great speed and travels up a ramp. The car flies through the air and just barely makes a landing on the roof of a building. Due to its large **horizontal velocity** the car skids across the roof surface while Bond applies the brakes, slowing down the car. The car stops just as it reaches the far edge of the roof.

In order for this stunt to be completed safely, you must ensure the car will make it onto the roof and stop in time.

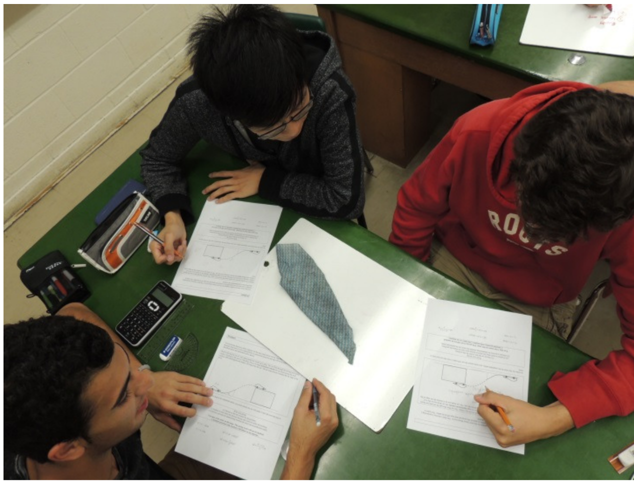
With your group:
(1) Decide on the key events for the problem.
(2) Explain to each other the physics during each interval within the problem.
(3) Discuss a process for determining whether the stunt can be performed safely.

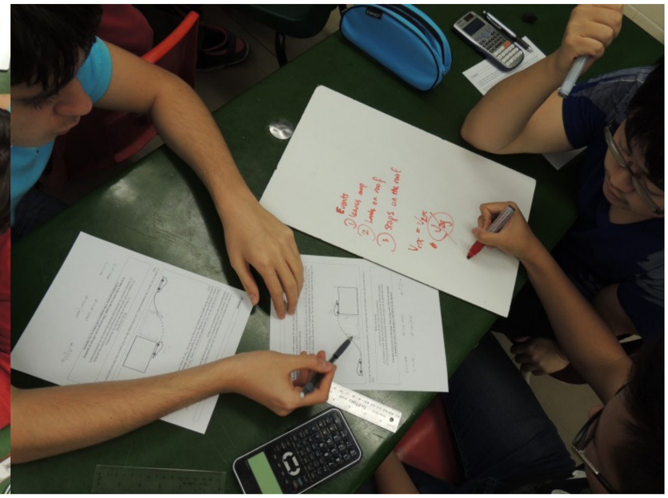
You may write notes on this page. This group work will not be marked.
A detailed question with numbers will follow in ten minutes.

$$\vec{v}_f^2 = \vec{v}_i^2 + 2\vec{a}\Delta d \qquad \Delta\vec{d} = \vec{v}_f\Delta t - \tfrac{1}{2}\vec{a}(\Delta t)^2 \qquad \Delta\vec{d} = \frac{(\vec{v}_i + \vec{v}_f)}{2}\Delta t$$

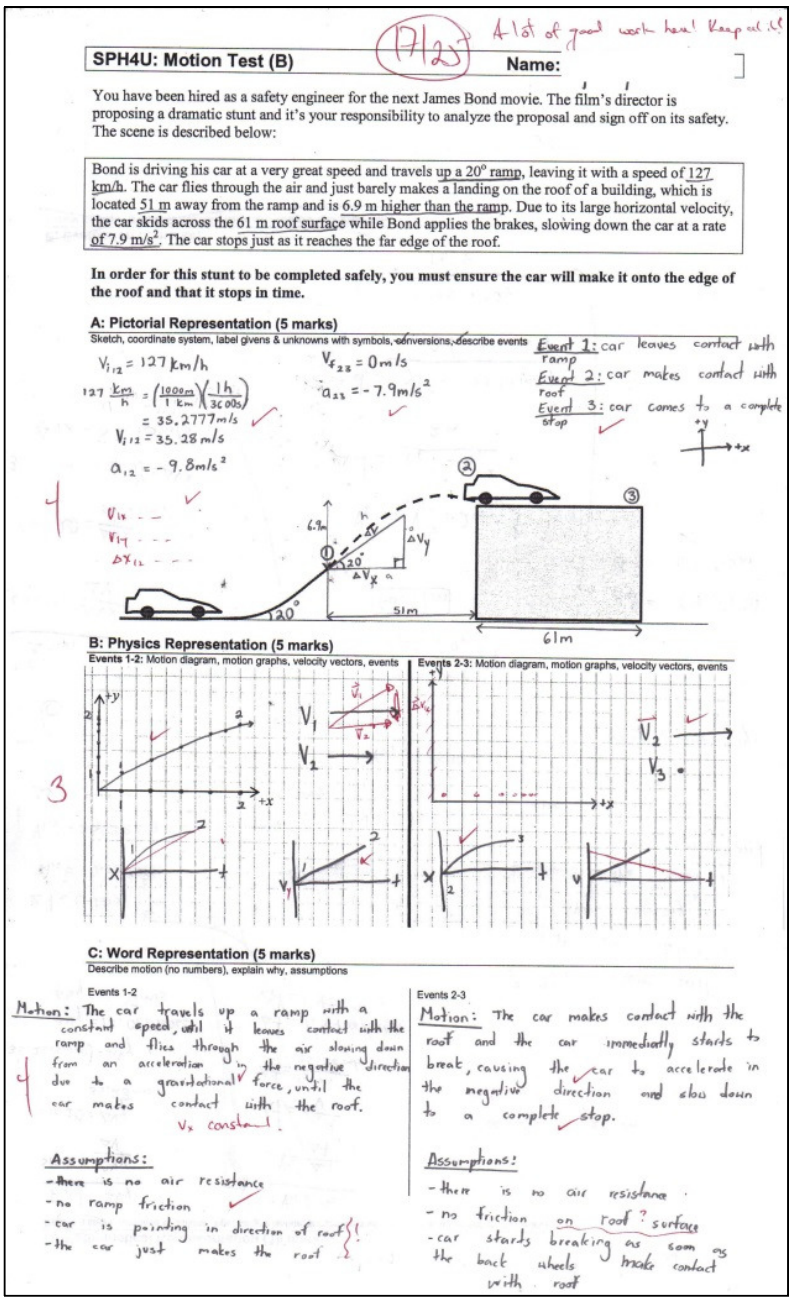
$$\vec{v}_f = \vec{v}_i + \vec{a}\Delta t \qquad \Delta\vec{d} = \vec{v}_i\Delta t + \frac{1}{2}\vec{a}(\Delta t)^2$$

And the group discussions began:





After 15 minutes, the individual part began. Here are two sample test results, the first a lower quartile test and the second a median test.



17/25 A lot of good work here! Keep at it!

SPH4U: Motion Test (B) Name:

You have been hired as a safety engineer for the next James Bond movie. The film's director is proposing a dramatic stunt and it's your responsibility to analyze the proposal and sign off on its safety. The scene is described below:

> Bond is driving his car at a very great speed and travels up a 20° ramp, leaving it with a speed of 127 km/h. The car flies through the air and just barely makes a landing on the roof of a building, which is located 51 m away from the ramp and is 6.9 m higher than the ramp. Due to its large horizontal velocity, the car skids across the 61 m roof surface while Bond applies the brakes, slowing down the car at a rate of 7.9 m/s². The car stops just as it reaches the far edge of the roof.

In order for this stunt to be completed safely, you must ensure the car will make it onto the edge of the roof and that it stops in time.

A: Pictorial Representation (5 marks)

Sketch, coordinate system, label givens & unknowns with symbols, conversions, describe events

$V_{i12} = 127\ km/h$

$127\ \frac{km}{h} \cdot \left(\frac{1000m}{1\ km}\right)\left(\frac{1h}{3600s}\right) = 35.2777 m/s$

$V_{i12} = 35.28\ m/s$

$a_{12} = -9.8 m/s^2$

$V_{f23} = 0\ m/s$

$a_{23} = -7.9 m/s^2$

Event 1: car leaves contact with ramp
Event 2: car makes contact with roof
Event 3: car comes to a complete stop

4

B: Physics Representation (5 marks)

Events 1-2: Motion diagram, motion graphs, velocity vectors, events

Events 2-3: Motion diagram, motion graphs, velocity vectors, events

3

C: Word Representation (5 marks)

Describe motion (no numbers), explain why, assumptions

Events 1-2

Motion: The car travels up a ramp with a constant speed, until it leaves contact with the ramp and flies through the air slowing down from an acceleration in the negative direction due to a gravitational force, until the car makes contact with the roof.

V_x constant.

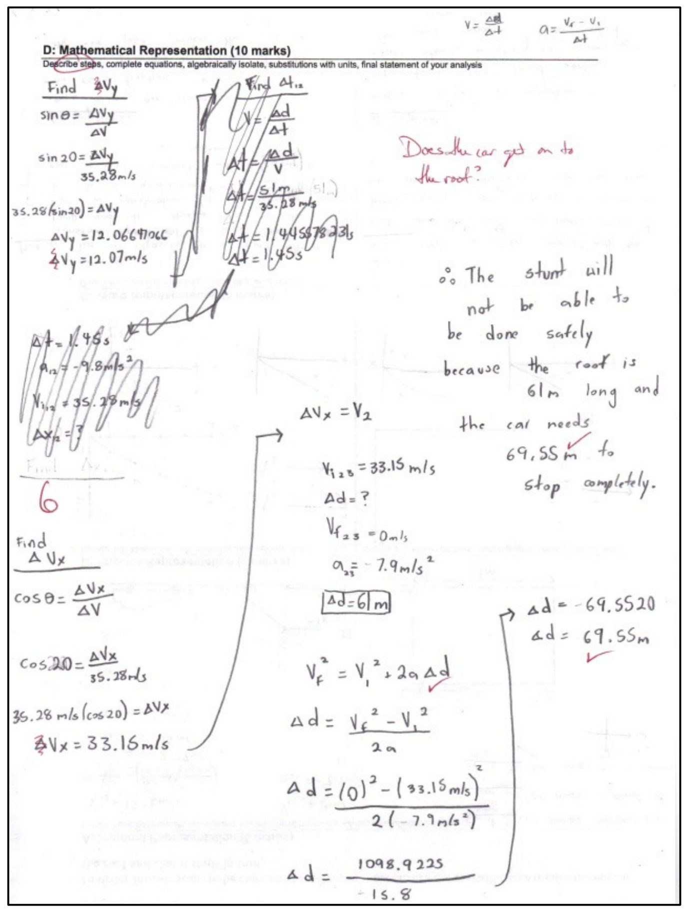
4

Assumptions:
- there is no air resistance
- no ramp friction
- car is pointing in direction of roof
- the car just makes the roof

Events 2-3

Motion: The car makes contact with the roof and the car immediatly starts to break, causing the car to accelerate in the negative direction and slow down to a complete stop.

Assumptions:
- there is no air resistance
- no friction on roof surface
- car starts breaking as soon as the back wheels make contact with roof



$v = \frac{\Delta d}{\Delta t}$ $a = \frac{v_f - v_i}{\Delta t}$

D: Mathematical Representation (10 marks)

Describe steps, complete equations, algebraically isolate, substitutions with units, final statement of your analysis

Find ΔV_y

$\sin\theta = \frac{\Delta V_y}{\Delta V}$

$\sin 20 = \frac{\Delta V_y}{35.28 m/s}$

$35.28(\sin 20) = \Delta V_y$

$\Delta V_y = 12.06647066$

$\Delta V_y = 12.07 m/s$

Does the car get on to the roof?

6

Find ΔV_x

$\cos\theta = \frac{\Delta V_x}{\Delta V}$

$\cos 20 = \frac{\Delta V_x}{35.28 m/s}$

$35.28 m/s(\cos 20) = \Delta V_x$

$\Delta V_x = 33.15 m/s$

$\Delta V_x = V_2$

$V_{i23} = 33.15 m/s$

$\Delta d = ?$

$V_{f23} = 0 m/s$

$a_{23} = -7.9 m/s^2$

$\Delta d = 61 m$

$V_f^2 = V_i^2 + 2a\Delta d$

$\Delta d = \frac{V_f^2 - V_i^2}{2a}$

$\Delta d = \frac{(0)^2 - (33.15 m/s)^2}{2(-7.9 m/s^2)}$

$\Delta d = \frac{1098.9225}{-15.8}$

$\Delta d = -69.5520$

$\Delta d = 69.55 m$

∴ The stunt will not be able to be done safely because the roof is 61 m long and the car needs 69.55 m to stop completely.

SPH4U: Motion Test (B) **Name:**

You have been hired as a safety engineer for the next James Bond movie. The film's director is proposing a dramatic stunt and it's your responsibility to analyze the proposal and sign off on its safety. The scene is described below:

(22/25)

Bond is driving his car at a very great speed and travels up a 20° ramp, leaving it with a speed of 127 km/h. The car flies through the air and just barely makes a landing on the roof of a building, which is located 51 m away from the ramp and is 6.9 m higher than the ramp. Due to its large horizontal velocity, the car skids across the 61 m roof surface while Bond applies the brakes, slowing down the car at a rate of 7.9 m/s^2. The car stops just as it reaches the far edge of the roof.

In order for this stunt to be completed safely, you must ensure the car will make it onto the edge of the roof and that it stops in time.

A: Pictorial Representation (5 marks)

Sketch, coordinate system, label givens & unknowns with symbols, conversions, describe events

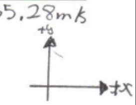
$v_1 = 127\ km/h \doteq 35.28\ m/s$

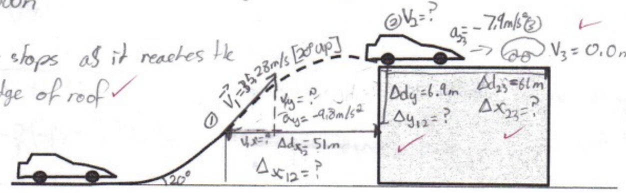
① Car leaves ramp ~~at 35.28 m/s [20° UP]~~

② Car lands on roof and begins to slow down

③ Car stops as it reaches the far edge of roof

5

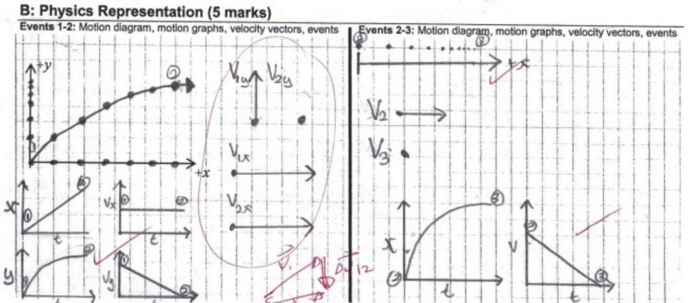




B: Physics Representation (5 marks)

Events 1-2: Motion diagram, motion graphs, velocity vectors, events | **Events 2-3:** Motion diagram, motion graphs, velocity vectors, events

4



C: Word Representation (5 marks)

Describe motion (no numbers), explain why, assumptions

Events 1-2

v_x const, a_y ---

4

The car leaves the ramp in the positive direction and lands on a roof higher than its starting position. We assume there is no air resistance and that when the car lands on the roof, it doesn't lose velocity due to the counter-acting normal force exerted by the roof. *it lost y-velocity!*

Events 2-3

The car begins to slow down as it moves along the roof until it comes to a complete stop. The car slows down because its acceleration is in the opposite direction (negative) to its initial velocity [positive]. We assume that there are no other factors to the car's acceleration other than the brakes.

$\vec{a}$ const.

D: Mathematical Representation (10 marks)

Describe steps, complete equations, algebraically isolate, substitutions with units, final statement of your analysis

9

④ Find v_{1x} (4th step)

$v_{1x} = v_1 \cos\theta$

$v_{1x} = 35.28\ m/s \cos 20°$

$v_{1x} = 33.15\ m/s$

② Find Δt

$v_{2y} = v_{1y} + a_y \Delta t$

$\frac{v_{2y} + v_{1y}}{a_y} = \Delta t$

$\frac{12.07\ m/s}{9.8\ m/s^2} = \Delta t$

$1.23\ s = \Delta t$

① Find v_{1y} (1st step)

$v_{1y} = v_1 \sin\theta$

$v_{1y} = 35.28\ m/s \sin 20$

$v_{1y} = 12.07\ m/s$

③ Find Δy_{12}

$\Delta y_{12} = -\frac{1}{2} a (\Delta t)^2$

$\Delta y_{12} = -\frac{1}{2}(-9.8\ m/s)(1.23\ s)^2$

$\Delta y_{12} = 7.41\ m$

⑤ Find Δx_{12}

$\Delta x_{12} = v_1 \Delta t$

$\Delta x_{12} = (33.15\ m/s)(1.23\ s)$

$\Delta x_{12} = 40.77\ m$

∴ The car does not reach the roof. Therefore is unable to complete the stunt

If the car reached the roof...

$v_2 = v_{1x}$

① Find Δx_{23}

$v_3^2 = v_2^2 + 2a_{23}\Delta x_{23}$

$\frac{v_3^2 - v_2^2}{2a_{23}} = \Delta x_{23}$

$\frac{-(33.15\ m/s)^2}{2(7.9\ m/s^2)} = \Delta x_{23}$

$69.55\ m = \Delta x_{23}$

$\Delta x_{23} > \Delta d_{23}$

∴ The stunt wouldn't be completed because the car would skid off the roof