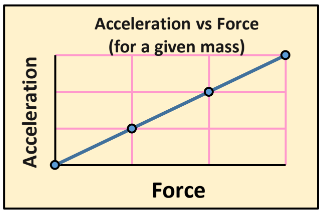
Shedding Light on Motion Episode 7: Newton's Second Law of Motion Question Sheet
Name: ____

Part B



1. What does the acceleration vs force graph tell you about the relationship between acceleration and force (if the mass is kept constant)?

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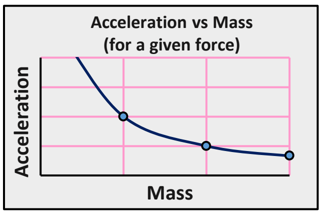

2. What does the acceleration vs mass graph tell you about the relationship between acceleration and mass (if the force is kept constant)?

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3. Newton's Second Law of Motion can be expressed as an equation: ________________________

   where F = ______________ measured in _______________ (N)

   m = ______________ measured in _______________ (kg)

   and a = _______________ measured in m/s/s (or m/s^2)

4. Re-arrange the equation in Q3 to make acceleration the subject. _______________________________
5. Re-arrange the equation in Q3 to make mass the subject. _______________________________
6. Calculate the force required to accelerate a 3000 kg truck at a rate of 1.5 m/s/s.

7. Calculate the force of gravity acting on a 1 kg ball that is in free fall (and accelerating at 9.8 m/s/s).

8. In a race, a 65 kg athlete accelerates from 0 to 8 m/s in 4 seconds. Calculate the force that the athlete generated.

9. The F = ma formula is more accurately written as F_{net} = ma. What does F_{net} mean?

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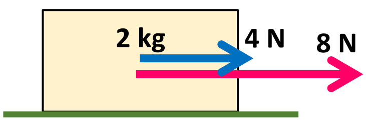
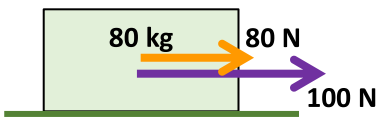
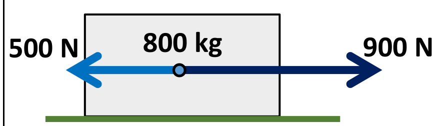
10. Calculate the net force (F_{net}) acting in the following situations **and** the acceleration that would be produced.







11. A full supermarket trolley is difficult to accelerate initially, but once you have reached a comfortable speed it becomes easier to push. Why is that?

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12. An aeroplane is flying in level flight at a constant velocity of 800 km/hr. The combined thrust of its engines is 300,000 Newtons.
   (a) If it is flying at a constant velocity, its acceleration must be _____________.
   (b) Therefore, according to the $F_{net} = ma$ formula, the net force acting on the plane must also be ____________.
   (c) Since the (forward) thrust = 300,000 N, the force of air resistance (acting in the opposite direction) must therefore also be _____________________.
   (d) Draw a diagram of the aeroplane showing the forces of thrust and of air resistance.

Part C

13. Explain the reason that a ball on a trolley will roll backwards (relative to the trolley) when the trolley is made to accelerate quickly.

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14. Explain why pulling on a tablecloth really quickly results in the tablecloth sliding out from under the dishes, but pulling on the tablecloth slowly results in the dishes sliding with the tablecloth.

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Part D

15. A truck engine is typically much more powerful than a car engine, but trucks typically accelerate at a much lower rate than cars. Why is this? ____

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16. Drag-racing cars are not fitted with brakes, a radiator, back seats or air conditioning, and their panels are made of lightweight materials like carbon fibre rather than steel. How does this help them to accelerate faster? ____

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17. Fill in the rest of the table to determine the effectiveness of slowing down slowly.

Mass of Occupant	Initial Speed	Final Speed	Time Taken to Come to a Complete Stop	Acceleration ($a = \Delta v/t$)	Force Applied on Occupant ($F = ma$)
60 kg	18 m/s	0 m/s	0.012 seconds (12 milliseconds)		
60 kg	18 m/s	0 m/s	0.106 seconds (106 milliseconds)		
60 kg	18 m/s	0 m/s	2 seconds		

18. How does increasing the time it takes to stop affect the force that is applied to an object?

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19. Describe what a crumple zone is and why it has become an essential part of every car that is built.

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20. What do seatbelts and air bags do? ____

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Part E

21. The force of gravity on every kilogram of mass on (or near) the earth's surface is _______ Newtons. We can write this information in shorthand by saying g = ______________.
22. Fill in the table below.

Mass of Object	**Force of Gravity Acting on Object (near the Earth's surface)**
10 kg	
50 kg	
250 grams	

23. Fill in the table below so as to calculate the acceleration of falling objects when the air resistance is zero.

Objects in Free Fall (with no air resistance)			
Mass of Object	**Force of Gravity on Object (F_g) ($F_g = mg$)**	**Net Force on Object, F_{net} (same as previous column since $F_{air\ resistance} = 0$)**	**Acceleration $a = F_{net}/m$**
1 kg			
2 kg			
10 kg			

24. What does the table above tell us about the force of gravity acting on a falling object and the effect that it has on the object's acceleration? ____
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25. Fill in the table below so as to calculate the acceleration of falling objects when the air resistance is not zero.

Objects in Free Fall (with air resistance)				
Mass of Object	**Force of Gravity (F_g)**	**Air Resistance ($F_{air\ resistance}$)**	**Net Force, F_{net} ($F_g + F_{air\ resistance}$) Don't forget direction!**	**Acceleration $a = F_{net}/m$**
1 kg	_________ downwards	2 N upwards		
2 kg	_________ downwards	2 N upwards		
10 kg	_________ downwards	2 N upwards		

26. When air resistance is significant, how does it affect the acceleration of objects that have different masses?
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27. What does terminal velocity mean?
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Part F

28. In everyday language, the words "mass" and "weight" are used interchangeably, but how do scientists and engineers define "weight"? ____
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29. (a) If Apollo 15 astronaut Dave Scott (who performed the hammer and feather experiment on the moon) had a mass of 80 kg here on Earth, what was his mass on the moon? ___________________________
(b) His weight on Earth was ____________ Newtons and his weight on the moon was _____________ Newtons.
(c) If he had stepped onto a set of bathroom scales (marked in kilograms) on the moon, what would the scales have read? ____
30. On the International Space Station, the men and women and all the equipment are weightless. If an astronaut on the ISS wishes to accelerate a 10 kg water bag at a rate of 2 m/s/s, how much force needs to be applied?