Early E. C.: / 1
Total HW Points Unit 4: / 28
Total Lab Points Unit 4: / 58
Unit 4 Apps.: / 5
Late, Incomplete, No Work, No Units Fee? Y / N

Unit 4 – Dynamics (Forces)

Essential Fundamentals of Dynamics

1. Force is a push or a pull exerted on an object.

Add More!!!

Link to Algebra

In Unit 4, you will use the following equations. Isolate the indicated variables.

AP Equations

In-Class Equations

Fma or Newton's 2nd Law

$\vec{a} = \frac{\Sigma\vec{F}}{m} = \frac{\vec{F}_{net}}{m}$

$m =$

$\vec{F} =$

Force of Friction

$|\vec{F}_f| \leq \mu|\vec{F}_n|$

$\mu =$

$\vec{F}_n =$

Force of Gravity

$F_g = mg$

$m =$

Force of Kinetic Friction

$f_k = \mu_k N$

$\mu_k =$

$N =$

Force of Static Friction

$f_s \leq \mu_s N$

$\mu_s =$

$N =$

Force of Tension

$\vec{F}_T = mg$

$m =$

Air Friction

$ma = mg - f_{air}$

$a =$

$m =$

$f_{air} =$

Normal Force

$\vec{F}_n = mg$

$m =$

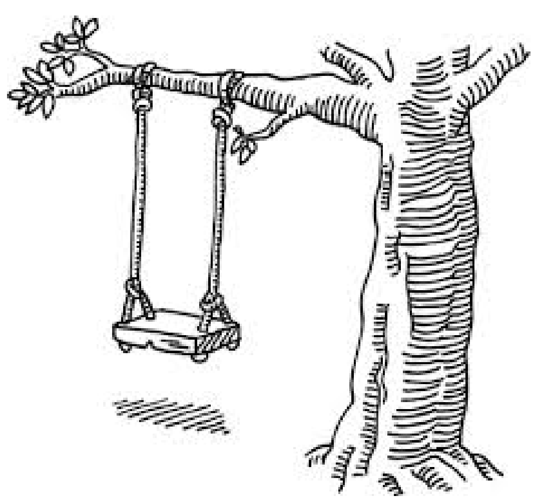
Possible 4.1 Pts.: 3
Late, Incomplete, No work, No Units Fee: - 1 - 2 - 3
Final Score: / 3

4.1 Problems – Newton's 1st Law of Motion - Inertia
Section 4.1 – 4.2 of your book.

1. Which has more inertia, 20.0 cm^3 of water, or 10.0 cm^3 of aluminum? You'll have to research and use the densities of water and aluminum to solve this.

2. When on a jet plane (or a car) that's accelerating, you feel that you are being "pushed" back into your seat. Use Newton's first law to explain why.

3. In the following picture, label the forces present. Label them as contact force or if it's a field force.



Possible 4.2 Pts.:	6
Late, Incomplete, No work, No Units Fee: - 1 - 2 - 3	
Final Score:	/ 6

4.2 Problems – Newton's 2nd Law of Motion – F = ma
Section 4.3 of your book.

1. A net force of 4.0 N gives an object an acceleration of 10.0 m/s^2. What is the mass of the object?

2. A. A 6.0 N net force is continuously applied to a 1.5-kg mass. What is the object's acceleration?

   B. How far will the object move in 3.5 seconds, assuming it starts from rest?

3. A. Two forces act on a 5.0-kg object sitting on a frictionless horizontal surface. One force is 30 N in the +x-direction, and the other is 35 N in the –x-direction. What is the net force acting on the object?

   B. What is the acceleration of the object?

   C. How far will the object move in 6.0 seconds, assuming it starts from rest?

Possible 4.3 Pts.:	5
Late, Incomplete, No work, No Units Fee:	- 1 - 2 - 3
Final Score:	**/ 5**

4.3 Problems – Newton's 3rd Law – Equal and Opposite Actions
Section 4.4 of your book.

1. A. In an Olympic figure skating event, a 65-kg male skater pushes a 45-kg female skater, causing her to accelerate at a rate of 2.0 m/s^2. What force did the female skater experience as the male skater pushed her?

   B. At what rate will the male skater accelerate, and in what direction relative to the female, assuming they start from rest?

2. A book sitting on a horizontal surface receives a horizontal push. Identify the forces acting on the book, in terms of action and reaction pairs.

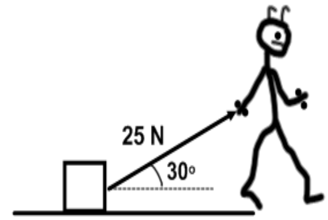
3. A. During a daring rescue, a helicopter initially accelerates a 25.0-kg girl vertically off the roof of a burning building with a lowered rope, which she hangs on to as they pull her up. Neglect the mass of the rope. What force causes the girl to accelerate vertically upward: (a) her weight; (b) the pull of the helicopter on the rope; (c) the pull of the girl on the rope; (d) the pull of the rope on the girl? Explain completely why you chose your answer.

   B. In the previous problem, determine the tension in the rope if the girl initially accelerates upward at 0.750 m/s^2.

Possible 4.4 Pts.:	9
Late, Incomplete, No work, No Units Fee: - 1 - 2 - 3	
Final Score:	/ 9

4.4 Problems – Free Body Diagrams
Section 4.5 of your book.
Wizard Challenge Alert!

1. A. A boy pulls a box of mass 30.0 kg with a force of 25.0 N in the direction shown in the figure. Make a free body diagram with respect to the box, showing the forces and directions.



.

B. Ignoring friction, what is the acceleration of the box? Hint: only the component of tension in the x-direction matters

C. For the previous problem, what is the normal force exerted on the box by the ground?

2. A 75.0-kg person is standing on a scale in an elevator. What is the reading on the scale (in N) if the elevator is
   a. at rest?
   b. moving up at a constant velocity?
   c. accelerating upward at 2.00 m/s^2?
   d. accelerating downward at 2.00 m/s^2?

3. A. A 105 kg gymnast hangs vertically from a pair of parallel rings connected to the ceiling above. Make a free body diagram of this.

B. What is the tension in each rope?

Possible 4.5 Pts.:	5
Late, Incomplete, No work, No Units Fee: - 1 - 2 - 3	
Final Score:	/ 5

4.5 Problems – Friction

Section 4.6 of your book.

1. The coefficient of static friction between a 50.0-kg box and a horizontal surface is 0.500. What is the maximum force of static friction between the box and the floor?

2. A. The coefficient of kinetic friction between a 50.0-kg box and a horizontal surface is 0.400. What is the force of kinetic friction between the moving box and the ground?

   B. What is the acceleration of the box if a 250.0-N horizontal force is applied to it?

3. In moving a 35.0-kg desk from one side of a classroom to the other, a professor finds that a horizontal force of 275 N is necessary to set the desk in motion, and a force of 195 N is necessary to keep it in motion at a constant speed.
   A. What is the coefficient of static friction?

   B. What is the coefficient of kinetic friction?

AP Physics 1	4.1 Lab - Balloon Car Challenge
Reminder: Update Table of Contents	Correction Credit: Half

Challenge: Your team (three people maximum) must design and build a vehicle powered by a balloon that exemplifies Newton's Third Law of Motion: "For every action, there is an equal and opposite reaction."

Your objective is to have the vehicle that travels the farthest during a best of three and average of three trials competition.

Balloon Car Lab (4.1) Scoring Guide		
Table of Contents, Title/Date, Detailed Synopsis, Two Purposes		/ 2
Design	Full Page	/ 1
	Labeled:	/ 1
	Dimensions:	/ 1
	Materials List:	/ 1
	Neatly Drawn:	/ 2
	4 gram component:	/ 2
Performance: 8 Floor Tiles		1 2 3 4
Extra Credit:	Farthest:	+ 1
	15 Tiles:	+ 1
Penalties:	Not Ready Registration	-2
	Not Ready Race Day	-3
	More than 2 Balloons	-1
	Bad Sportsmanship	-1
Question 1: Improvements		/ 2
Question 2: Strong Features		/ 2
Question 3: Applied Force		/ 2
Question 4: Friction		/ 2
Late Lab Fee		-5
Total:		**/ 22**

Balloon Rocket Parameters:

1. This vehicle can be an airship or a ground based device.
2. It can have a built-in guidance system, but no part of the car can extend past the starting line at the time of launch.
3. There should be at least one component (> 4.0 g) connected to the balloon.
4. Rockets will be launched in the hallway, starting at the double doors and heading north. Distance is measured from the start/stopping point of the intact balloon.
5. Each group will get two official balloons for free; after that – they cost points.
6. The only allowable source of propulsion is one provided balloon, and that propulsion shall come from the expulsion of air through the inlet port of the balloon.
7. Balloon rockets will start on the floor, unassisted by your guidance system.
8. No pre-made balloon cars are allowed. Please create your own new entry.

Timeline:

a. Day 1 - Challenge issued.
b. Day 2 - 30 minutes design time.
c. Day Before Race (will be a Monday) - Balloon Car Registration (-2 points if not ready)
d. **Race Day** (will be a Block Day) – Car is completely ready to go (-3 points if not).

Mission 1: Design & Performance Points

a. Full page, clearly labeled with dimensions.
b. Materials list present.
c. Neatly drawn - pretend this could win you a major contract.

2. There is at least one four gram component connected to the balloon (2 points).
3. The vehicle passes at least eight floor tile lengths forward (4 points).

Extra Credit:

(+1 E. C.) Your group's vehicle goes the farthest on any of the three trials.
(+1 E. C.) Your vehicle goes more than 15 tiles.

Penalty Points:

(-2 Points) Your group's vehicle not ready to roll at registration.
(-3 Points) Your group's vehicle is not ready to go on Race Day.
(-1 pt/balloon) Your group's vehicle requires more than two balloons.
(-1 pt/infraction) Good sportsmanship is required.

Questions: Rephrase and answer in complete sentences for full credit.

1. How could your balloon car have performed better?

2. What were some features of your car that you thought were strong?

3. A 1.50 N force is applied to a 198 gram balloon car in a frictionless environment. What is the acceleration of the car?

4. For the previous problem, if there is a frictional force of 0.45 N acting against the car, what is the acceleration now?

AP Physics 1	4.2 Lab - Tension	
Reminder: Update Table of Contents		Correction Credit: Half

Lab Overview:

Working in small groups, use the construction equipment to build a frame that supports a system of ropes and tension meters.

Your objective is to assemble a functional lab setup to measure tension in a system in static equilibrium.

Tension Lab (4.2) Scoring Guide		
Table of Contents, Title/Date, Detailed Synopsis, Two Purposes		/ 2
Mission 1.A	FBD w/ Whole Forces (Symbolic):	/ 2
Mission 1.B	FBD w/ Decomposed Forces (Numeric):	/ 4
Mission 2	Data Table:	/ 4
Question 1: Compare Forces Along y-axis.		/ 3
Question 2: Compare Forces Along x-axis.		/ 3
Late Lab Fee		-4
Total:		**/ 18**

Materials:

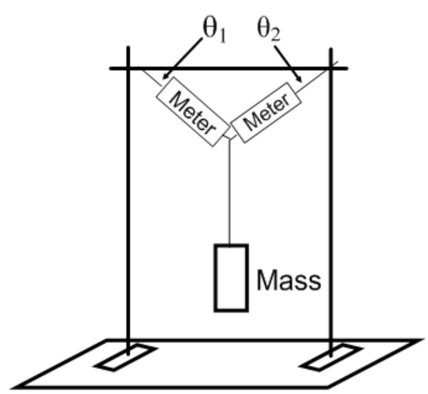
1 – Base Plate
2 – Threaded Base Attachment Brackets
2 – Long Rods (threaded)
1 – Crossbar
2 – 90º Skew Connectors (wing nuts)
2 – Zeroed 5 N Tension Meters
50.0 g Weight Hanger
Pac-Man Shaped Weight Set
Strings
Anglometer (Protractor)

Setup:

Design a system that is in static equilibrium with string, weights, tension meters, and other components from the construction equipment. This system must have only two ropes connecting the frame to a hanging mass (see picture).

Build your system so that the tension of all ropes can be measured. Do NOT max out the tension meters with too much weight! They are not all rated the same. Also, if there is not enough weight, your ropes may sag a little. Use as much weight as necessary to prevent slack from forming, without breaking the tension meters.

The angles of the strings with respect to the upper crossbar must NOT be equal.



Mission 1

Create two free body diagrams of your system:

A. (2 Points) One FBD showing all non-decomposed forces (and angles) present in <u>symbolic</u> form (F_g, T_1, T_2, θ_1, θ_2). The nexus of force is where the two strings and the hanging mass join. Make sure your angles are to scale.

B. (4 Points) The second FBD must show the decomposed (x and y components) tension vectors from your first free body diagram, in numeric form. In other words, the two measured tensions should take the place of T_1 and T_2, your F_g should be calculated, etc.

Mission 2

Make a neat data table that includes all of the possible force related information in your lab (decomposed as well as overall).

Questions: Rephrase and answer in complete sentences for full credit.

1. Add the decomposed tension vectors along the y-axis together and report it. How does this value compare to the calculated force of gravity acting on your mass? Is it close to equal and opposite? What could account for differences? Explain fully.

2. Compare the decomposed tension vectors along the x-axis. Are they close to equal and opposite of each other? What do you think could account for differences? Explain fully.

AP Physics 1	4.3 Lab - Friction
Reminder: Update Table of Contents	Correction Credit: Half

Lab Overview:

In this lab, you will work in teams using the friction lab equipment to determine coefficients of static (μ_s) and kinetic (μ_k) friction for a material (of your choosing) against a steel plate.

Friction Lab (4.3) Scoring Guide		
Table of Contents, Title/Date, Detailed Synopsis, Two Purposes		/ 2
Mission 1: Static Friction	Average μ_s	/ 2
	Data Table	/ 4
Mission 2: Kinetic Friction	Average μ_k	/ 2
	Data Table	/ 4
Question 1: Compare Coefficients of Friction		/ 2
Question 2: Difficulties		/ 2
Late Lab Fee		-4
Total:		**/ 18**

Equipment:

Tension meters: 2.5 N, 5 N, 20 N
Sliding friction plates: wood, steel, HDPE, etc
Stationary steel friction plates
Set of masses
Low quality strings connecting plates to meters.

Mission 1: Static Friction (6 Points)

Devise a method of determining the minimum force required to make a friction plate move from rest. Using the acquired data, you can calculate μ_s. Using at least 3 increasingly massive weights, find an average of your μ_s values.

Make a data table that includes all masses used for the different measurements, normal force calculations, measured values of tension, calculated values of friction coefficients, etc. I will use your table to check your results. Don't forget units!

Mission 2: Kinetic Friction (6 Points)

Devise a method of determining the minimum force required to make a friction plate move with a constant velocity. Using your data, you can calculate μ_k. Take data using several weights in order to find an average μ_k.

Make a data table that includes all masses used for the different measurements, normal force calculations, calculated values of friction coefficients, measured values of tension, etc. I will use your table to check your results. Don't forget units!

Questions: Rephrase and answer in complete sentences for full credit.

1. How do the values of μ_k compare to μ_s? Explain any differences.

2. What were some difficulties that you encountered in acquiring data? Be complete in your description, and include suggestions for improvement.

AP Physics 1	Unit 4 - Dynamics (Forces)				
Application Problems, AP Test Preparation Questions					
Presentation Points:	/ 5	Late Fee:	-2	Completion (Booklet Check)	/ 5

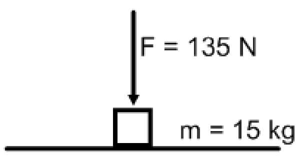
Your grade on this problem set will depend on the presentation you provide for your problem, and whether they are complete when you submit your Booklet at the end of the Unit.

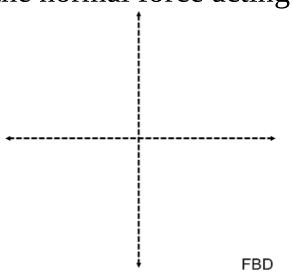
Make free body diagrams of all the sketches, then solve the related problem. Be sure to clearly label each force acting in the sketch.

You will be graded on how well you answer whichever question(s) you get at random, so be prepared to answer all of them!

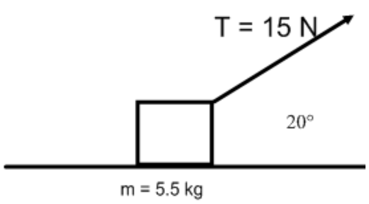
Part 1. Make free body diagrams of all the sketches, then solve the related question(s). Clearly label each force acting on the box.

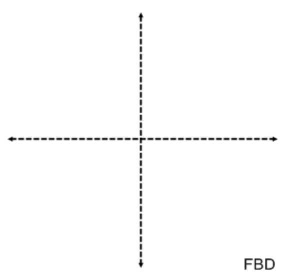
1. Calculate the normal force acting on the box.



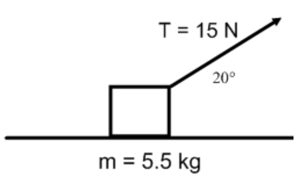


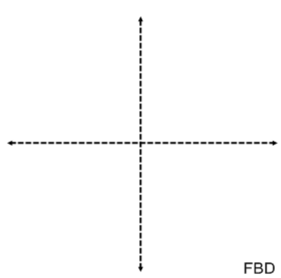
2. Calculate the normal force acting on the box.



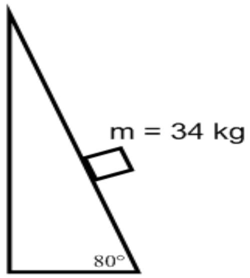


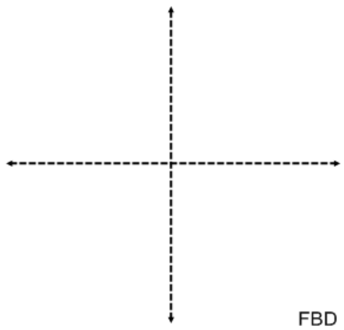
3. If the coefficient of kinetic friction = 0.14, what will the acceleration be?



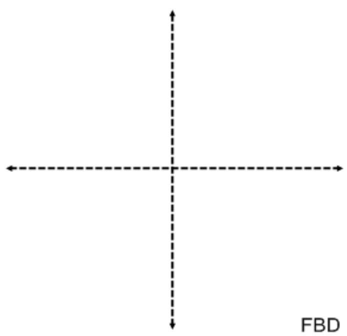


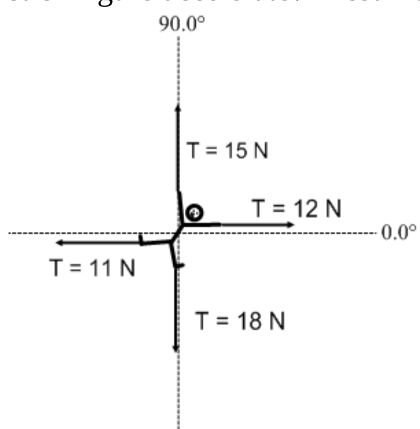
4. What is the normal force acting on the box?



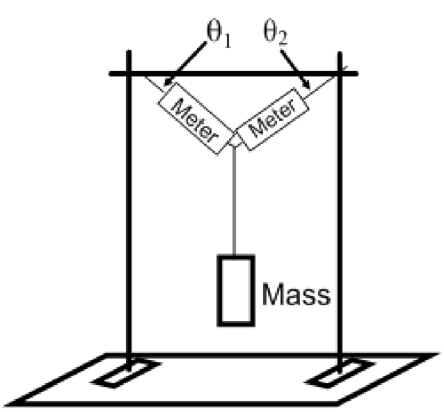


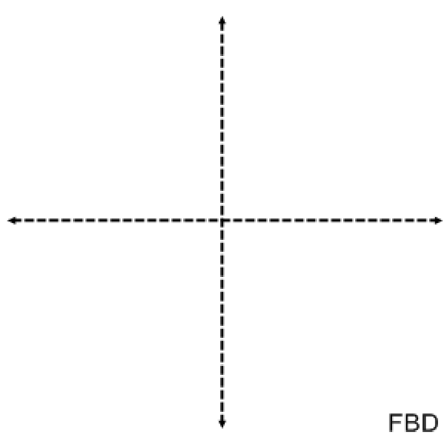
5. At what angle will the stick figure accelerate? Assume the tension vectors are aligned with the axes of the grid.

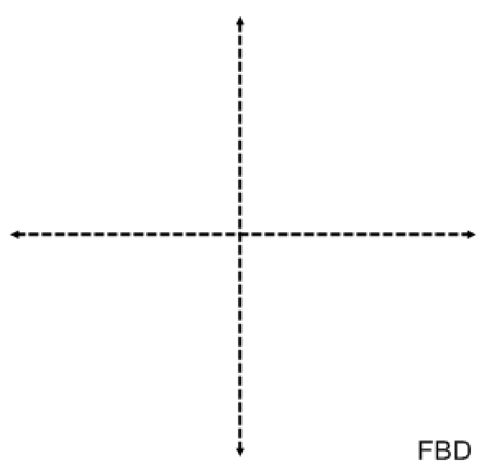




6. Make a free body diagram for the junction of the ropes, then show that it is in translational equilibrium.







Unit 4 Practice AP Multiple Choice Questions

The following problems (multiple choice and free response) are designed to train you to take the AP Physics 1 test in the spring, and will be scored at the end of the Unit – based on completion and accuracy.

1. A wooden block slides directly down an inclined plane, at a constant velocity of 6.0 m/s. How large is the coefficient of kinetic friction, μ_k, if the plane makes an angle of 25.0° with the horizontal?

   A. 1.2 B. 0.42 C. 0.47 D. 0.37 E. 0.91

2. A person who weighs 800 N steps onto a scale that is on the floor of an elevator car. If the elevator accelerates upward at a rate of 5 m/s^2, what will the scale read?
   a. 400 N b. 800 N c. 1000 N d. 1200 N

3. A person standing on a horizontal floor feels two forces: the downward pull of gravity and the upward supporting force from the floor. These two forces
   a. have equal magnitudes and form an action/reaction pair.
   b. have equal magnitudes but do not form an action/reaction pair.
   c. have unequal magnitudes and form an action/reaction pair.
   d. have unequal magnitudes and do not form an action/reaction pair.

4. A frictionless inclined plane of length 20 m has a maximum vertical height of 5.0 m. If an object of mass 2.0 kg is placed on the plane, which of the following best approximates the net force it feels?
   a. 5 N b. 10 N c. 15 N d. 20 N

5. A 20 N block is being pushed across a horizontal table by an 18 N force. If the coefficient of kinetic friction between the block and the table is 0.4, find the acceleration of the block.
   a. 0.5 m/s^2 b. 1 m/s^2 c. 5 m/s^2 d. 7.5 m/s^2

6. The coefficient of static friction between a box and a ramp is 0.5. The ramp's incline angle is 30°. If the box is placed at rest on the ramp, which of the following will it do?
   a. Accelerate down the ramp.
   b. Accelerate briefly down the ramp but then slow down and stop.
   c. Move with constant velocity down the ramp.
   d. Not move.

7. If all of the forces acting on an object balance so that the net force is zero, then
   a. the object must be at rest.
   b. the object's speed will decrease.
   c. the object's direction of motion can change, but not its speed.
   d. none of the above will occur.

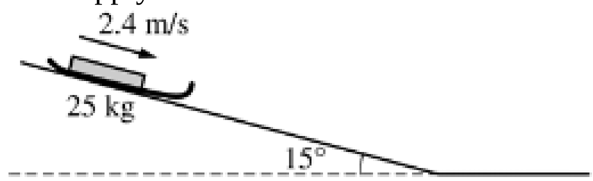
8. A block of mass *m* is at rest on a frictionless, horizontal table placed in a laboratory on the surface of the Earth. An identical block is at rest on a frictionless, horizontal table placed on the surface of the Moon. Let **F** be the net force necessary to give the Earth-bound block an acceleration of **a** across the table. Given that g_{Moon} is 1/6 of g_{Earth}, the force necessary to give the Moon-bound block the same acceleration **a** across the table is:
   a. **F**/6 b. **F**/3 c. **F** d. 6**F**

9. A 100-kg crate is at rest on a horizontal floor. The coefficient of static friction between the crate and the floor is 0.4, and the coefficient of kinetic friction is 0.3. A force **F** of magnitude 344 N is then applied to the crate, parallel to the floor. Which of the following is true?
   a. The crate will accelerate across the floor at 0.5 m/s^2.
   b. The static friction force, which is the reaction force to **F** as guaranteed by Newton's Third Law, will also have a magnitude of 344 N.
   c. The crate will slide across the floor at a constant speed of 0.5 m/s.
   d. The crate will not move.

10. Two crates are stacked on top of each other on a horizontal floor; Crate 1 is on the bottom. Both have the same mass. Compared to the strength of the force $\mathbf{F_1}$ necessary to push only crate 1 at constant speed across the floor, the strength of the force $\mathbf{F_2}$ necessary to push the stack at the same constant speed across the floor is greater than $\mathbf{F_1}$ because
    a. the normal force on Crate 1 is greater
    b. the coefficient of kinetic friction between Crate 1 and the floor is greater.
    c. the coefficient of static friction between Crate 1 and the floor is greater.
    d. the weight of Crate 1 is greater.

Unit 4 Example AP Question – Free Response

Note: Point values listed do not apply.

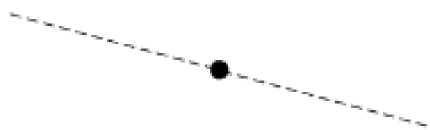


1. (15 points)

An empty sled of mass 25 kg slides down a muddy hill with a constant speed of 2.4 m/s. The slope of the hill is inclined at an angle of 15° with the horizontal as shown in the figure above.

(a) Calculate the time it takes the sled to go 21 m down the slope.

(b) On the dot below that represents the sled, draw and label a free-body diagram for the sled as it slides down the slope.



(c) Calculate the frictional force on the sled as it slides down the slope.

(d) Calculate the coefficient of friction between the sled and the muddy surface of the slope.

(e) The sled reaches the bottom of the slope and continues on the horizontal ground. Assume the same coefficient of friction.

i. In terms of velocity and acceleration, describe the motion of the sled as it travels on the horizontal ground.

ii. On the axes below, sketch a graph of speed v versus time t for the sled. Include both the sled's travel down the slope and across the horizontal ground. Clearly indicate with the symbol t_ℓ the time at which the sled leaves the slope.

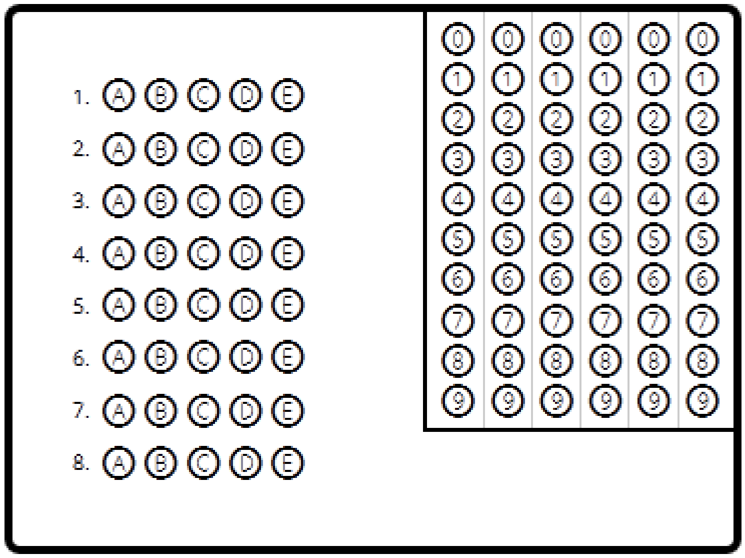
AP Physics 1	Unit 4 Review - Dynamics (Forces)						
Points:	**/ 20**	**Late or Incomplete Fee:**	**-2 -4 -6**	**Correction Credit:**		**Final Score:**	

Solve these problems here, THEN enter your responses in the bubble sheet provided. On the due date, I will scan your responses in class, mark which problems you missed, and enter your score in Powerschool.

If you submit your responses on time, you will have one attempt to correct errors you made (for half credit back).

If you are late, you will only get one attempt, and will only receive half credit for the problems you got right.

Each question is worth two points, and when I check your Booklets I will take points off for correct problems that show no work (1 point per problem).



1. A 15.0 N net force is applied to a 2.5 kg mass. What is the object's acceleration?

A) 0.17 m/s^2 B) 37.5 m/s^2 C) 12 m/s^2 D) 6.0 m/s^2 E) 8.5 m/s^2

2. A force acts on a 1.5 kg mass, giving it an acceleration of 3.0 m/s^2. What is the magnitude of the force?

A) 4.5 N B) 2.0 N C) 0.5 N D) 1.0 N E) 1.5 N

3. If the same force acts upon a 2.5 kg mass, what acceleration would be produced?

A) 3.75 m/s^2 B) 1.8 m/s^2 C) 3.6 m/s^2 D) 2.5 m/s^2 E) 2.81 m/s^2

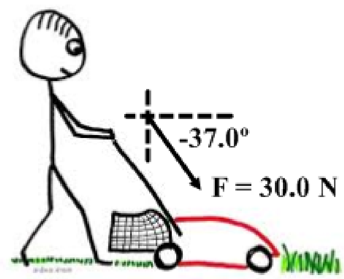
4. A student weighing 800. N crouches on a scale and suddenly springs vertically upward. The scale reads 900. N momentarily just as he leaves it. With what acceleration does he leave the scale (just before he is in the air)?

A) 1.23 m/s^2 B) 11.0 m/s^2 C) -9.81 m/s^2 D) 10.2 m/s^2 E) 8.00 m/s^2

5. A 68 kg male skater pushes a 50 kg female skater, causing her to accelerate at a rate of 2.4 m/s^2. At what rate will the male skater accelerate?

A) 1.38 m/s^2 B) 1.25 m/s^2 C) 0.85 m/s^2 D) 2.1 m/s^2 E) 1.8 m/s^2

6. A boy pushes a 25.0 kg lawnmower along level ground at a downward angle of -37.0º, with a force of 30.0 N. Make an FBD to help your computation. What is the acceleration of the mower?



A) 0.96 m/s^2 B) 1.2 m/s^2 C) 2.4 m/s^2
D) 0.72 m/s^2 E) 0.92 m/s^2

7. What is the normal force exerted on the mower by the lawn in the previous problem?

A) 18.1 N B) 245 N C) 269 N D) 263 N E) 150 N

8. A 40.0 kg crate is at rest on a level surface. If the coefficient of static friction between the crate and the surface is 0.69, what horizontal force is required to get the crate moving?

A) 27.6 N B) 270 N C) 0.69 N D) 392 N E) 166 N