AP Physics 1- Dynamics Practice Problems **ANSWERS**

FACT: Inertia is the tendency of an object to resist a change in state of motion. A "change in state of motion" means a change in an object's velocity, therefore inertia can also be defined as the tendency of an object to resist acceleration. Inertial mass is a measure of an object's inertia. In other words, inertial mass is a measure of the tendency of an object to resist acceleration. The more mass something has, the more it resists acceleration. There is also gravitational mass, which is experimentally identical to inertial mass.

FACT: A force is often defined as a push or a pull on an object. A force is the ability to cause a change in state of motion of an object. Therefore, a force is what has the ability to cause an acceleration and mass is the measurement of how much an object resists that acceleration. Because force is *the ability* to cause a change in state of motion of an object, it doesn't have to cause acceleration ($\Sigma F_{net} = ma$)

FACT: There are two types of forces. *Contact forces* are the result of two objects touching one another. Examples of contact forces are applied forces, drag force, friction force, force normal, spring force and tension. *Field forces* happen even when two interacting objects are *not touching* one another. Examples of Field forces are gravitational force, magnetic force and electric force.

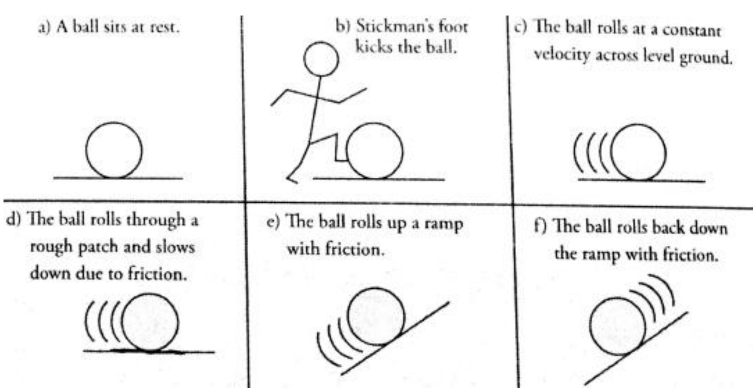
Q1. An object feels two forces; one of strength 8 N pulling to the left and one of 20 N pulling to the right. If the object's mass is 4 kg, what is its acceleration? (3 m/s^2 to the right)

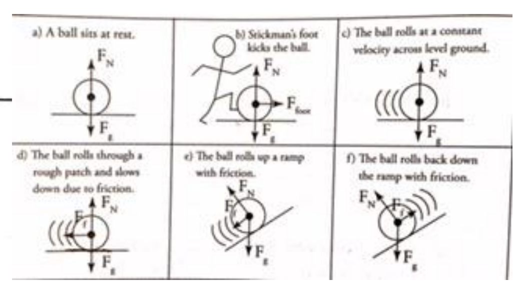
Q2. A book whose mass is 2 kg rests on a table. Find the magnitude of the force exerted by the table on the book. (20N)

Q3. What is the mass (in both kg and pounds) of an object that weighs 500N? There are 2.2 lbs./1kg. (50 kg, 110 pounds)

FACT: Free-body diagrams (FBD) are diagrams used to show the relative magnitude and direction of all forces acting upon an object in a given situation. These diagrams will be used throughout our study of physics. The size of the arrow in a free-body diagram reflects the magnitude of the force. The direction of the arrow shows the direction that the force is acting. Each force arrow in the diagram is labeled to indicate the exact type of force.

Q4. Draw free-body diagrams (FBD) for the following six scenarios.





Q5. A can of paint with a mass of 6 kg hangs from a rope. If the can is to be pulled up to the rooftop with an acceleration of 1 m/s^2, what must the tension in the rope be? (66 N)

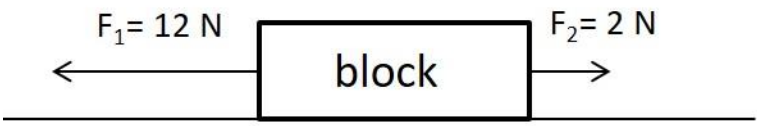
Q6. A bucket of water with a mass of 4 kg hangs from a rope. If the bucket is to be pulled up to the rooftop with a constant velocity of 1 m/s, what must the tension in the rope be? (40 N)

Q7. How much tension must a rope have to lift a 50 N object with an acceleration of 10 m/s^2? (100 N)

Q8. A pair of fuzzy dice is hanging by a string from your rearview mirror. You speed up from a stoplight. During the acceleration, the dice do not move vertically; the string makes an angle of 22° with the vertical. The dice have a mass of 0.10 kg. Sum the forces in the x and y to determine the acceleration. ($T = 1.1$ N; $a_y=0$; $a_x=4.1$ m/s^2)

Q9. In the question above, how would the tension in the string change if the angle from the vertical increased? (Make up a calculation and justify the answer based on that calculation, so for example, call angle theta 60. Solving give T = 2 N; the tension would increase, although the vertical (y) component must be the same since the mass is the same)

Q10. Two forces, F_1 and F_2 are applied to a block on a frictionless, horizontal surface as shown below. If the magnitude of the block's acceleration is 2.0 m/s^2, what is the mass of the block? (5 kg)



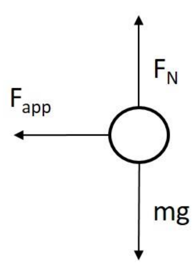
Q11. A 0.15-kg baseball moving at 20 m/s is stopped by a catcher in 0.010 s. Find the average force to stop the ball.

(Use kinematics to find acceleration = -2000m/s/s; Next use 2nd law to find force of -300 N; discuss the negative sign on the force)

Q12. A 25-N horizontal force northward and a 35-N horizontal force southward act concurrently on a 15-kg object on a frictionless surface. What is the magnitude of the object's acceleration?

(0.67 m/s/s; discuss the concept of northward horizontal and southward horizontal)

Q13. A cardboard box of mass *m* on a wooden floor is represented by the FBD below. Given this information, derive two expressions that are accurate representations for the box.



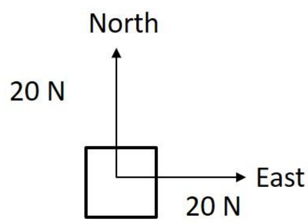
$\boxed{-F_{app} = ma_x \text{ and } F_N - mg = ma_y}$

FACT: With regards to Newton's 1st and 2nd laws, the two most common mistakes students make are underlined here: An object at rest will remain at rest and an object in motion will remain <u>at a constant velocity</u> unless acted upon by a <u>net external</u> force. Students will often say that on object in motion will remain in motion, which is not correct. Students will often leave off the "net external". ($\Sigma F_{net} = ma$)

Q14. You apply a force of 8.0 N horizontally to a 1 kg book that is at rest on a horizontal table. If the force of friction between the book and table is 4 N: a) What are the magnitudes of all the forces acting on the book? b) What is the acceleration of the book? (10N = F_N and $F_{gravity}$; 4.0 m/s^2)

Q15. A 500 g cart is released from rest on a horizontal track and travels 75.0 cm in 1.75 seconds while experiencing an average, horizontal applied force of 0.5 N. What is the magnitude of the force of friction between the cart and the track? (a= 0.49 m/s^2; F_f=0.26 N)

Q16. A 20-N force due north and a 20-N force due east act concurrently on an object, as shown in the diagram below.



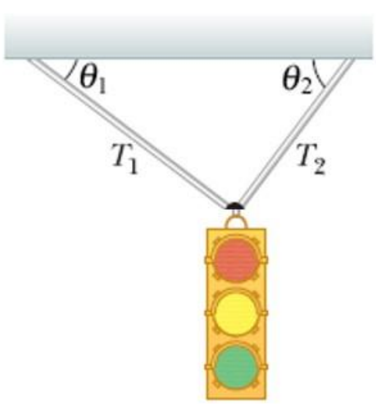
What additional force is needed to bring the object into a state of equilibrium? (the resultant is 28 N northeast, so the equilibrant must be 28 N southwest)

Q17. A 1.0 N metal disk rests on an index card that is balanced on top of a glass. What is the net force acting on the disk? (0-Newtons; the disk is at rest and not accelerating)

Q18. A 15-kg wagon is pulled to the right across a surface by a tension of 100 N at an angle of 30 degrees above the horizontal. A frictional force of 20 N to the left acts simultaneously. What is the acceleration of the wagon?(F = ma → 86.6-20 = ma_x → a_x = 4.44 m/s/s)

FACT: Tension Force or the Force of Tension (T or F_T) is the force transmitted through a rope, cable, string or wire pulled taut by forces acting on both ends. The Tension Force, like all forces, is a vector and has both magnitude and direction. The direction is always a pull in the direction of the rope and in opposite directions on opposite ends of the rope. The magnitude is equal in magnitude on both ends of the rope.

Q19. A traffic light is suspended by two cables as shown in the diagram. If cable 1 has a tension of 49 N and $\theta 1 = 30°$ and cable 2 has a tension force of 85 N and $\theta 2 = 60°$, find the mass of the traffic light.

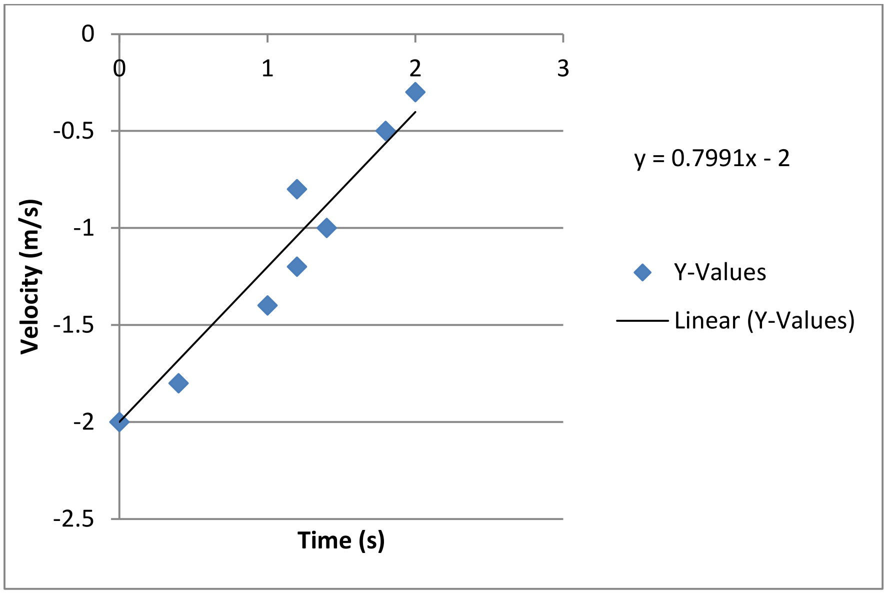


F = Tsin 30 + Tsin60 – mg = 0

m = 10 kg

Q20. Three students are pulling on a bag of skittles. Each is pulling with a horizontal force. If student 1 pulls Eastward with 170 N, student 2 pulls Southward with 100 N and student 3 pulls with 200 N at an angle of 20° W of N, what is the net force caused by the three students on the bag of skittles? (135 N at 41 degrees north of east)

Q21. You slide a 300 gram wooden block across the benchtop and record the velocity as a function of time. From these data you draw a best fit linear regression. The graph of its velocity as a function of time is shown below. (a).What is the magnitude of the force of friction between the book and the benchtop? (b). What else could you determine from this graph? (F_f=0.24 N; μ = 0.08; negative velocity means moving from right to left; positive slope means the magnitude of velocity is decreasing, so the acceleration is positive; area under the graph represents the displacement ~1.6 m.; draw position time)



FACT: Newton's Third Law states that in every interaction, there is a pair of forces acting on the two interacting objects. The size of the forces on the first object equals the size of the force on the second object. The direction of the force on the first object is opposite to the direction of the force on the second object. Forces always come in pairs - equal and opposite action-reaction force pairs For example, if someone throws a ball at my head, the force the ball exerts on my head is equal in magnitude and opposite in direction to the force my head exerts on the ball.

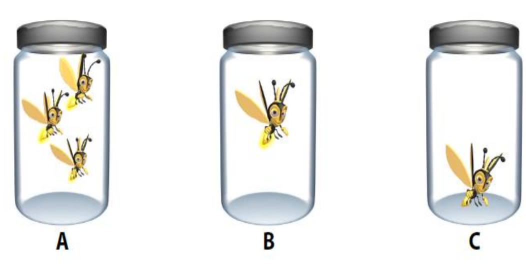
Q22. Draw a FBD for a book with mass (3 kg) resting on a table. Sum the forces to find force normal. Explain why the force of gravity and the force normal are **not** a Newton's Third Law Force Pair.

(Note that the two forces act on the same object. Newton's Third Law Force Pairs always act on two different objects. The Force Normal is the force the table applies upward on the book. Therefore, the Newton's Third Law force that makes the Force Pair with the Force Normal is the force the book applies downward on the table. The Force of Gravity is the force the Earth applies downward on the book. Therefore, the Newton's Third Law force that makes the Force Pair with the Force of Gravity is the force the book applies upward on the Earth.)

Q23. A man with a mass m stands on a scale in an elevator. If the scale reading is equal to mg when the elevator is at rest, what is the scale reading while the elevator is accelerating downwards with a magnitude of a? Answer is terms of variables (m, a_y, g). $m(g-a_y)$

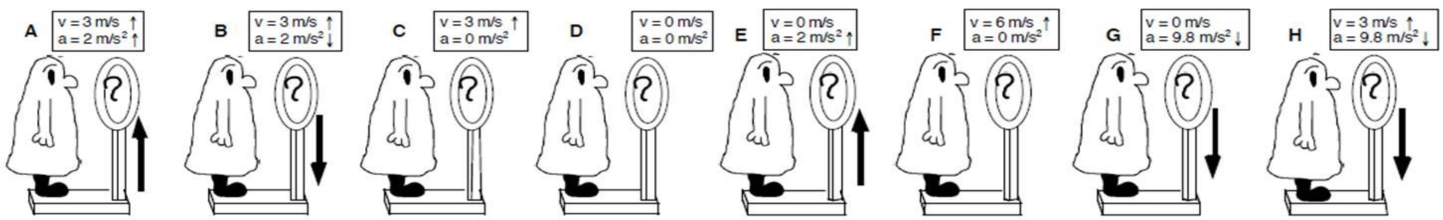
Q24. A person stands on a scale in an elevator. If the scale reads 600 N when that person is riding upward at a constant velocity of 4 m/s, what is the scale reading when the elevator is at rest? (600 N)

Q25. Identical fireflies are placed in closed jars in three different configurations as shown to the right. In configuration A, three fireflies are



hovering inside the jar. In configuration B, one firefly is hovering inside the jar. In configuration C, one firefly is sitting at rest on the bottom of the jar. Each jar is placed upon a scale and measured. Rank the weight of each jar according to the scale reading from heaviest to lightest. If jars have the same scale reading, rank them equally. (A, B=C)

Q26: The figures below depict situations where a person is standing on a scale in eight identical elevators. Each person weighs 600 N when the elevators are stationary. Each elevator now moves (accelerates) according to the specified arrow that is drawn next to it. In all cases where the elevator is moving, it is moving upward. Rank the figures, from greatest to least, on the basis of the *scale weight* of each person as registered on each scale. (AE, CDF, B, GH)



Q27. Four blocks of masses 20kg, 30kg, 40kg, and 50kg are stacked on top of one another in an elevator in order of decreasing mass with the lightest mass on the top of the stack. The elevator moves downward with an acceleration of 3.2 m/s ^{2}. Find the contact force between the 30kg and 40kg masses.

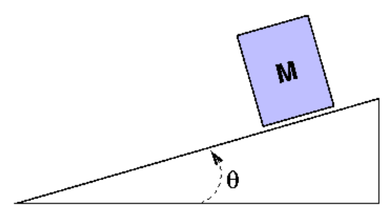
(When the elevator is in free fall, one will experience weightlessness. With that said, if the elevator is accelerating downward at a fraction of g, one's apparent weight will be less than his/her true weight. With your tip, I see where I went wrong and contact force between the 30kg and 40kg block should be the difference of the two forces which is a magnitude of 340 N.) $F = ma - mg \rightarrow F = (50)(3.2) – (50)(10) = 340$ N (magnitude)

FACT: The friction force is the force exerted by a surface as an object moves across it or makes an effort to move across it. There are at least two types of friction force - kinetic and static friction. Friction results from the two surfaces being pressed together closely, causing intermolecular attractive forces between molecules of different surfaces. As such, friction depends upon the nature of the two surfaces and upon the degree to which they are pressed together. The maximum amount of friction force that a surface can exert upon an object can be calculated using the formula $F_f = \mu F_N$, where μ, (*mu)* is the coefficient of friction, a proportionality constant that is specific to the two materials in contact and is dimensionless.

Q28. Calculate the coefficient of friction (μ) for the data graphed in question 21. ($\mu = 0.08$)

FACT: Kinetic friction is weaker than static friction, as it is easier to keep an object sliding once it is sliding than to start an object sliding in the first place (Newton's 1st law). Therefore there are two types of μ, denoted with subscripts. For a given pair of surfaces, it is true that $\mu_k < \mu_s$.

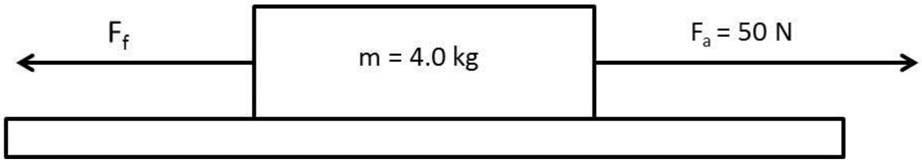
Q29. The diagram to the right shows a block sliding down a plane inclined at an angle θ with the horizontal at a constant velocity. As the angle θ is increased, what can be concluded about the coefficient of kinetic friction between the bottom surface of the block and the surface of the incline? (remains the same; μ depends only on the surfaces in contact)



Q30. The diagram below shows a 4.0-kg object accelerating at 10 m/s² to the right on a rough horizontal surface. What is the magnitude of the frictional force (F_f) acting on the object? Given these values, how much would the mass of the block need to be to experience no net force?

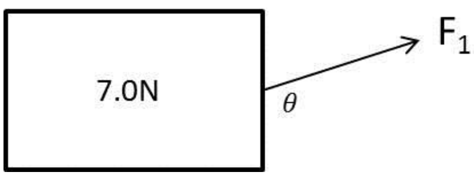
a). F_f = 50N-(4kg)(10 m/s/s) = 10 N

b). Find μ = 0.25 sub into equation if the form F_N(0.25) and solve for F_N and divide by 10 to get 20kg

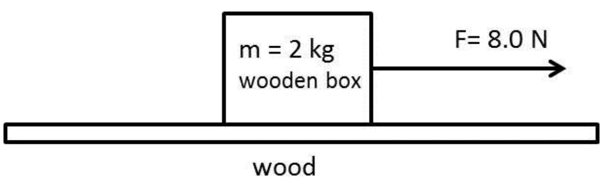


Q31. A 7.0 N block sits on a rough surface. It is being pulled by a force (F_1) at an angle of θ=30° above the horizontal, as shown below. The block is initially moving to the right with a speed of 5 m/s. The coefficient of friction between the block and the surface is μ=0.20. a). Is it possible for the block to be slowing down? If so, give a possible value of the magnitude of F_1 that would allow the block to slow down. If not, explain why not with reference to Newton's second law. b). In order to double the block's initial speed to 10 m/s, how must the magnitude of the force F_1 change?

(a. When an object slows down the acceleration and therefore, the net force, is in the opposite direction. In this case, a net force to the left would slow the object down. To make the net force to the left, F_1 to the right must be less than the friction force to the left. Remember F_1 is F_1 cos (30). Any value of F1 that is less than 1.4 N will work- try it out to see. b). The net force is related to acceleration, but it has no effect on speed. We do not know what occurred before to cause the initial speed, so we do not know how the initial speed came about. The forces can all be as indicated and the object could have any initial speed)



Q32. A horizontal tension force of 8.0 N is used to pull a 20-N wooden box moving toward the right along a horizontal, wood surface, as shown. The coefficient of kinetic friction for wood on wood is μ = 0.3.



a). Calculate the magnitude of the frictional force on the box; b). Identify Newton's Third Law Force Pairs; c). Determine the magnitude of the force acting on the box; d). Calculate the magnitude of the acceleration of the box.

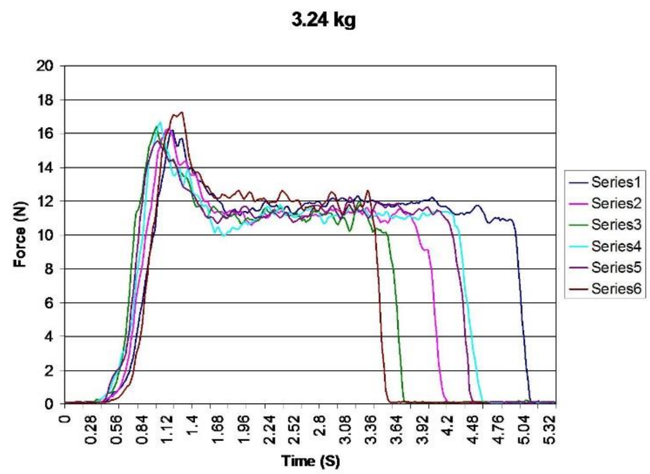
a). 6N; b. The 3rd law pairs in this example are: - rope pushes on the block (the applied force) and the block pushes back on the rope with an equal and opposite force; - the wood surface exerts a friction force on the block and the block exerts an equal and opposite friction force back on the wood surface. c). 2N; d). 1.0 m/s/s)

Q33. A 10-kg wooden box sits on a wood surface. The coefficient of static friction between the surfaces is 0.42. A horizontal force of 20 N is applied to the box. What is the force of friction on the box?

(find the max force friction as 0.42x10x10 = 42N; the force of friction will match the force applied because it is in static equilibrium as long as applied force less than 42 N. Force of friction must be 20 N)

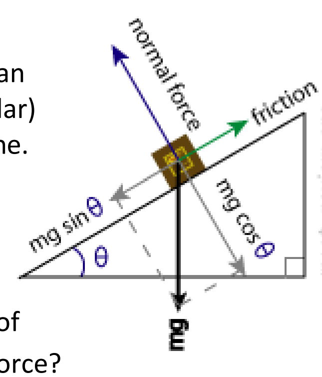
Q34. A crate of mass 100 kg rests on the floor (μ_s = 0.4) If a force of 250 N parallel to the floor is applied to the crate, will it move? If so, what is the coefficient for kinetic friction? If not, what is the magnitude of the force of static friction on the crate? (it does not move; F_{sf} = 250N because we need a force of 400N to move the crate, so $F_{sf} = F_a$)

Q35. A group of PCHS Magnet students want to explore the relationship between the force of static and kinetic friction across a horizontal desktop. They decide to perform a drag test by dragging a 3.24-kg block using a force probe to collect data. The students decide to perform six trials to ensure the data can be replicated. Their graph of force as a function of time can be seen below. a). Calculate the approximate coefficient of static friction (max) and the coefficient of kinetic friction using the data graphed below. b). Explain why the coefficient of static friction is greater than the coefficient of kinetic friction. ($\mu_{sf\ max} = 0.49 \quad \mu_{kf} = 0.34$) (It is more difficult to start an object in motion than to keep it in motion)



Q35. You apply a horizontal force of 3.0 Newtons to a book with a mass of 0.8 kg. The values for the coefficients of friction between the book and the incline are $\mu s = 0.3$ and $\mu k = 0.25$. (a) Does the book move? (b) What is the acceleration of the book? (Yes, the book will move to the right; $a_x = 0.75$ m/s^2)

Q36. A 1200-kg car with anti-lock brakes driving on snow has an initial velocity of 15 m/s and slows to a stop in 5.0 seconds. Determine the coefficient of friction between the tires and the snow. (Find $a_x = -3.0$ m/s^2; sum forces and cancel mass → $\mu = -a_x/g = 0.3$)

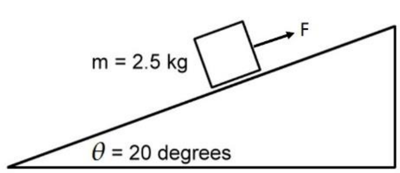


FACT: Previously, we resolved the vectors into components in the x and y directions, however, on an incline we usually resolve vectors into components which are in the ∥ (parallel) and ⊥ (perpendicular) directions. The ∥ direction is parallel to the incline and the ⊥ direction is perpendicular to the incline.

FACT: The component of gravity that is ⊥ to the incline is equal to mg cos Θ. The component of gravity that is ∥ to the incline is equal to mg sin Θ. Examine the diagram to the right.

Q37. A 2.5-kg mass is held at rest on a frictionless 20° incline by a force, F. What is the magnitude of F? Given this calculated force, determine what angle of inclination would result in a net external force?

(F = mg sin Θ; F = 8.6 N; any angle greater than 20 degrees would result in an acceleration)



Q38. A 10-kg box slides down a frictionless 18° ramp. Find the acceleration of the box, and the time it takes the box to slide 2 meters down the ramp. (gsin18=a → a = 3.1 m/s^2; using UAM equation → t = $\sqrt{\frac{2x}{a}}$ = 1.14 s; note the solution has no dependence on mass)

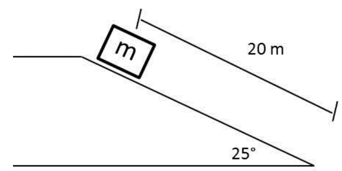
Q39. A block weighing 10 newtons is on a ramp inclined at 30° to the horizontal. A 3-newton force of friction acts on the block as it is pulled up the ramp at a constant velocity. The force applied to pull the box up the ramp acts parallel to the incline. Draw the FBD for this problem and determine the magnitude of the force applied. (8 N)

Q40. A 10-kg box is released from rest and slides 20 meters down a 40 degree incline as shown below. A frictional force of 10 N acts on the object. Determine: a). the acceleration of the block down the plane; b). the time for the block to slide to the bottom of the plane. (a = 5.4 m/s^2 down the plane; t = 2.7 s)

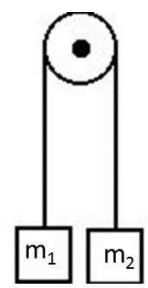
Q41. A box of unknown mass is released from rest and slides 20 meters down a 10-meter high frictionless incline. Determine: a). the acceleration of the block down the plane; b). the time for the block to slide to the bottom of the plane. (use trig. to find ϴ= 30°, realize mass is not a factor, a = 5.0 m/s^2 down the plane; t = 2.8 s)

Q42. A 10-kg is released from rest and slides 20 meters down 40° incline with a coefficient of kinetic friction of 0.25. Determine: a). the acceleration of the block down the plane; b). the time for the block to slide to the bottom of the plane. (a = 4.5 m/s^2 down the plane; t = 3.0 s)

Q43. A 30-kg box is 20 m up a ramp sliding with an initial velocity of 3.0 m/s up the ramp. The plane makes a 25° incline from the horizontal and the surface has a coefficient of kinetic friction of μ = 0.30. Determine: a). the acceleration of the block down the plane; b). the time for the block to slide to the bottom of the plane. (Think about this for a minute- the force of friction changes directions in this problem, so you need two steps; upward: a = 6.8 m/s^2; t = 0.4 s; downward: a = 1.5 m/s^2; t = 5.2 s)

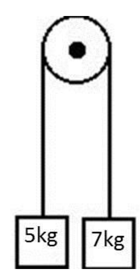


FACT: Pulleys, Atwood machines, and modified Atwood machines: An Atwood machine typically involves a pulley, a string, and system of masses. To solve these problems, recognize that the force transmitted by a string, known as tension, is constant throughout the string, and choose a consistent positive direction for the entire system to solve for acceleration.

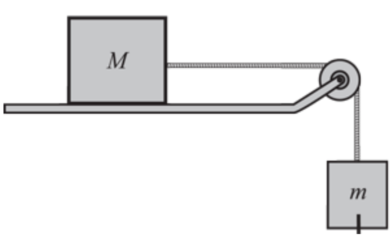


Q44. Two masses are hanging by a massless string from a frictionless pulley. If m_1 is greater than m_2, determine the acceleration of the two masses when released from rest. (a = $g\frac{(m1-m2)}{m1+m2)}$)

Q45. Two masses are hung from a frictionless pulley by a massless string as shown in the image to the right. How far will the 7-kg mass fall in 2 seconds if released from rest? (a = 1.63 s; Δy = 3.27 m)

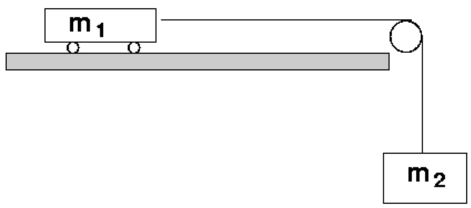


Q46. Two masses, *M* and *m*, are connected by a light string over a massless pulley as shown in the modified Atwood machine below. Assuming a frictionless surface, find the acceleration of *m.* (a = $g\frac{(m)}{M+m)}$)

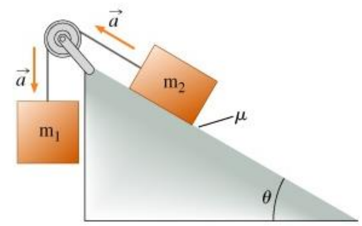


FACT: Since Atwood machine problems include a tension force, you may be asked to solve for F_T. Just remember to treat the entire machine as system in order to solve for acceleration (choose + direction) and then you can solve for any other variables.

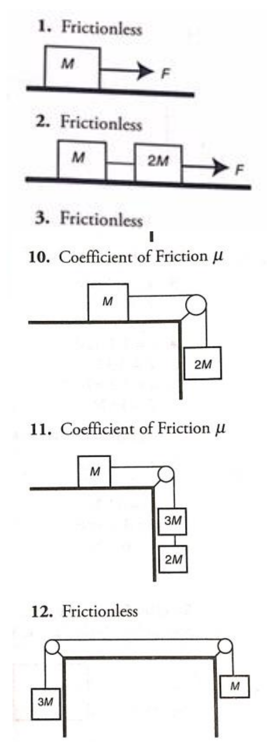
Q47. In the diagram below, the mass of m_1 is 2-kg and the mass of m_2 is 10-kg. The wheels on the cart are jammed and do not roll, so the coefficient of kinetic friction between the cart and the rough surface is 0.5. Find the acceleration of the system. (a= 7.5 m/s^2)



Q48. In the diagram below, the mass of m_1 is 8-kg and the mass of m_2 is 2-kg. The coefficient of kinetic friction between the block and the incline is 0.2 and the plane rises 25° from the horizontal. Find the acceleration of the system and the force of tension in the string. (a = 6.8 m/s^2; T_1 = 25.6 n; T_2 = 25.6 N)



Q49. The following question has three parts (1-3). For each part, find the force of tension in the rope and the acceleration of the set of masses. Use the following variable definitions: *F* = 10 N, *M* = 1.0 kg, μ = 0.2. (part 1: a = 10 m/s^2; part 2: a = 3.3 m/s^2, T = 3.3 N; part 3: a = 1.7 m/s^2, T_1 = 1.7 N, T_2 = 5.1 N) Two ways to solve- as system or by algebraically summing equations

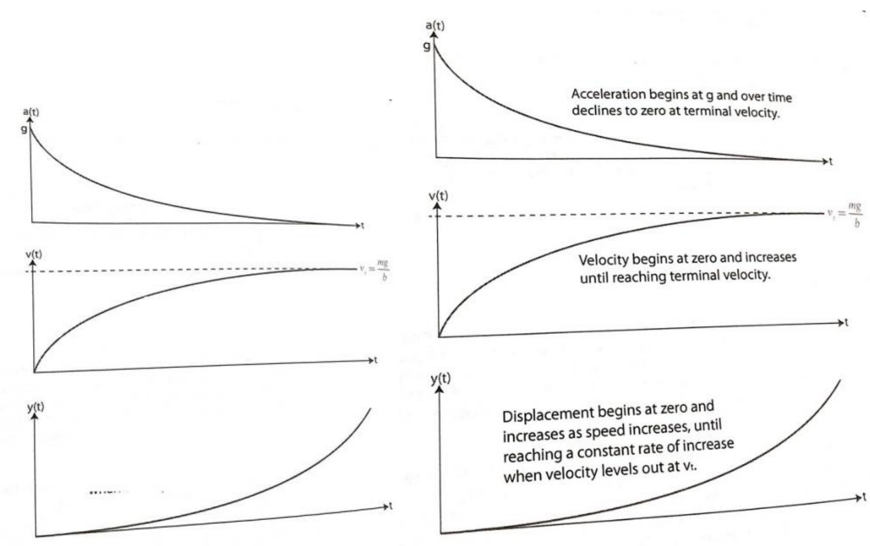


Q50. The following question has three parts (10-12). For each part, find the force of tension in the rope and the acceleration of the set of masses. Use the following variable definitions: *F* = 10 N, *M* = 1.0 kg, μ = 0.2. (part 10: a = 6.0 m/s^2, T = 8.0N; part 11: a = 8.0 m/s^2, T_1 = 10N, T_2 = 4.0N; part 12: a = 5.0 m/s^2, T = 15 N)

FACT: Air Resistance: As an object falls through air, it usually encounters some degree of air resistance. Air resistance is the result of collisions of the object's leading surface with air molecules. The actual amount of air resistance encountered by the object is dependent upon a variety of factors. To keep the topic simple, it can be said that the two most common factors that have a direct effect upon the amount of air resistance are the speed of the object and the cross-sectional area of the object. Increased speeds result in an increased amount of air resistance. Increased cross-sectional areas result in an increased amount of air resistance.

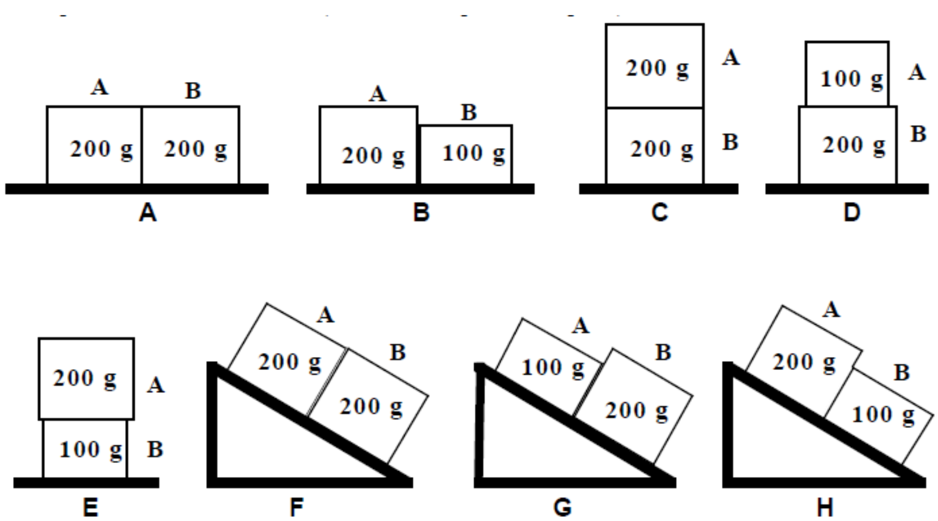
FACT: The drag forces on a free-fall object take a form similar to $F_{drag} = bv$ or $F_{drag} = cv^2$, where b and c are constants. When an object reaches its maximum vertical velocity, known as terminal velocity (V_t), the object falls at a constant velocity and is in equilibrium. It is unlikely you will encounter any mathematical problems dealing with air resistance on the AP Physics 1 exam; however, the concept might be assessed. I have also found that students are very curious about the concept of terminal velocity. For those curious about the complexity of the mathematics used to calculate the drag force, please view the following podcast:
https://www.youtube.com/watch?list=PLPyapQSxH6mY_hbPFnqgb_Ru_gKos6mab&v=OukRTF6Bgcc

Q51. Examine the following motion-time graphs for an object in free-fall. Write a sentence describing the motion for each graph.



Q52. Shown below are eight arrangements of two wooden blocks. There are two different mass blocks, either 100 g or 200 g. In all of the arrangements, the blocks are in contact, that is, they are touching each other. Also, in all of the arrangements the blocks are at rest, i.e., they are not moving. As you can see, one of the blocks given in each arrangement is labeled **A,** and the other is labeled **B**. The mass of each block is given in the figures.

Rank these arrangements from largest to smallest on the basis of the difference of the strengths (magnitudes) of the forces between the force **A** exerts on **B** and the force **B** exerts on **A**. In other words, the arrangement where the force **A** exerts on **B** minus the force **B** exerts on **A** is the largest will rank first. In the same way, the arrangement where the force **A** exerts on **B** minus the force **B** exerts on **A** is the smallest will rank last. Keep in mind that some of these values might be negative. If **B** is exerting a stronger force on **A** than **A** exerts on **B**, then the difference will be negative.



All the same- 0

Largest 1 _____ 2 _____ 3 _____ 4 _____ 5 _____ 6 _____ 7 _____ 8 _____ Smallest

Or, all of these differences will be the same. _______