AP Physics C Name: _____

Unit 2: Forces Test

Part 1: Multiple Choice - Choose the answers that best answers the questions below. If an exact answer is not present, chose the closest available answer. (4 points each)

1. The position vs. time function for a 2.0 kg particle is given by $x(t) = \frac{4}{\sqrt{t}} + e^{2t}$. Find the net force on the particle at t = 1.0 s.

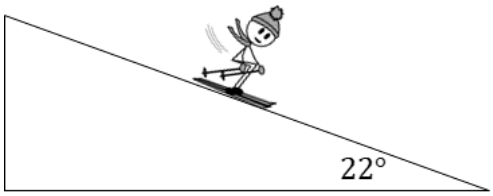
A) 61.1 N B) 20.8 N C) 12.8 N D) 25.6 N E) 65.1 N

2. A student pulls a cart across a surface with a constant force and the cart accelerates. This is repeated for several trails with different force constant. Friction is not negligible. The data are recorded in the table below.

Trial	1	2	3	4	5
Force (N)	0.32	0.38	0.44	0.50	0.60
Acceleration (m/s^2)	0.12	0.22	0.33	0.50	0.70

Which of the following is the best estimate for the mass of the cart?

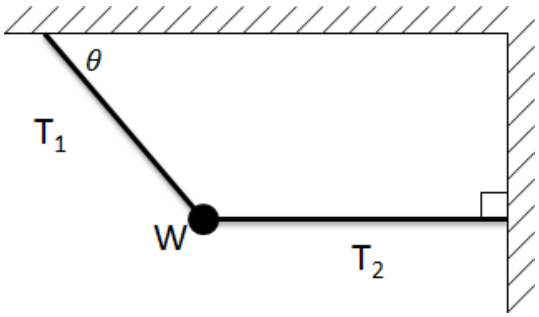
A) 2.7 kg B) 2.1 kg C) 1.7 kg D) 0.5 kg E) 0.9 kg



3. Sindri Svenson the Skiing Swede skies swiftly down a snowy slope at constant speed. The slope makes an angle of 22° with the horizontal. Find the coefficient of kinetic friction between the skier and incline.

A) 2.45 B) 0.37 C) 0.93 D) 0.01 E) 0.40

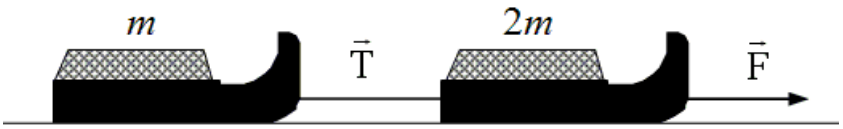
4. A mass of weight W is suspended from two massless strings as shown.



What is the tension in string T_2?

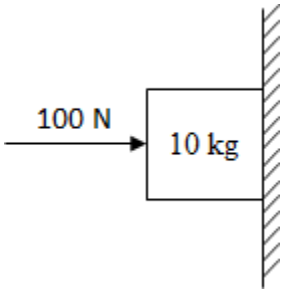
A) $W\cos\theta$ B) $\frac{W}{\tan\theta}$ C) $\frac{W}{\cos\theta}$ D) $W\sin\theta$ E) $W\sin\theta$

5. Two sleds are hooked together in tandem as shown in the figure. The front sled is twice as massive as the rear sled. The sleds are pulled along a frictionless surface by an applied force F. The tension in the rope between the sleds is T. Determine the value of the ratio of the magnitudes of the two forces, $\frac{T}{F}$.

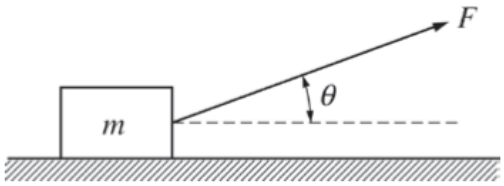


A) 0.67 B) 0.67 C) 0.50 D) 0.33 E) 2.0

6. A 10-kg block is pushed against a vertical wall by a horizontal force of 100 N as shown. The coefficient of static friction, μ_s, between the block and the wall is 0.60; and the coefficient of kinetic friction, μ_k, is 0.40. Which one of the following statements is true, if the block is initially at rest?



A) The total force exerted on the block by the wall is directed horizontally.
B) The block slides down the wall with an acceleration of magnitude 3.8 m/s^2.
C) The block will remain at rest because the coefficient of static friction is greater than the coefficient of kinetic friction.
D) The block will slide down the wall because the force of static friction can be no larger than 60 N.
E) The block will slide down the wall because the coefficient of kinetic friction is less than the coefficient of static friction.

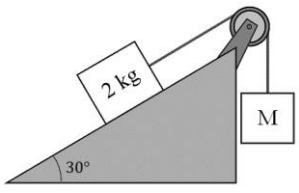


7. A block of mass m is pulled across a rough horizontal surface at constant speed by a force of magnitude F, which acts at angle of θ to the horizontal, as shown above. Which of the following represents the coefficient of kinetic friction between the block and the surface?

A) $\frac{F\sin\theta}{mg - F\cos\theta}$ B) $\frac{F}{mg}$ C) $\frac{F\cos\theta}{mg - F\sin\theta}$

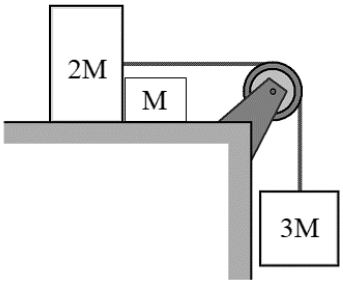
D) $\frac{F\cos\theta}{mg}$ E) $\frac{F\sin\theta}{mg}$

8. A block of mass 2 kg is placed on a rough inclined that is angled at 30° as shown. The coefficient of static friction between the block and incline is 0.60 and the coefficient of kinetic friction is 0.40. The block is connected via string over a frictionless pulley to a hanging block of mass M. The system is originally at rest. What is the maximum value of M for which the block will hang freely and not accelerate downwards?



A) 2.33 kg B) 1.69 kg C) 2.13 kg D) 2.69 kg E) 2.03 kg

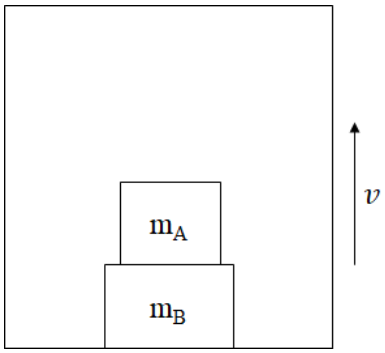
9. Consider the pulley system shown. A string connected a block 2M, which is placed on a frictionless table, runs over a frictionless pulley and is attached to hanging weight 3M, which accelerated downward. A block of mass M is in connect with the block of mass 2M, and is pushed by it. What is magnitude of the force of the block of mass M on the block with mass 2M?



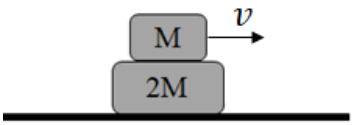
A) $\frac{Mg}{3}$ B) $3Mg$ C) $2Mg$

D) $\frac{Mg}{2}$ E) Mg

10. A box of mass m_A is placed on top of a box of m_B. The stacked boxes are placed in an elevator as shown with $m_B > m_A$. At the instant shown, the elevator is moving up and slowing down. F_A is the magnitude of the force on block m_A by block m_B, and F_B is the magnitude of the force on block m_B by block m_A. Which of the following relationships is correct?



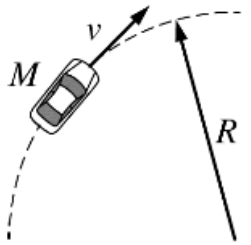
A) $m_A g < (F_A = F_B)$
B) $m_A g < F_A < F_B$
C) $F_A = F_B = m_A g$
D) $F_B < F_A < m_A g$
E) $(F_A = F_B) < m_A g$



11. A block of mass M is on top of a block of mass 2M. The lower block is on a horizontal surface, and a rope can pull horizontally on the lower block. The coefficient of kinetic friction for the surfaces bewteen the blocks is μ and there is no friction between the floor and the larger block. The top block slides to the right with some speed across the top block as shown. Which of the following gives the magnitude and direction of the acceleration of the bottom block?

A) $\frac{3\mu g}{2}$ to the right
B) $\frac{\mu g}{2}$ to the left
C) $\frac{3\mu g}{2}$ the left
D) $\frac{\mu g}{2}$ to the right
E) $\frac{\mu g}{3}$ to the left

12. Which of the following is true of the friction between the tires of the car and road if the car on the circular track shown is to remain in circular motion?



A) The coefficient of kinetic friction must be at least $\frac{rg}{v^2}$

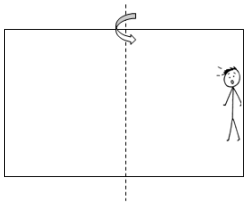
B) The coefficient of static friction must be at least $\frac{v^2}{2rg}$

C) The coefficient of kinetic friction must be at least $\frac{v^2}{rg}$

D) The coefficient of static friction must be at least $\frac{v^2}{rg}$

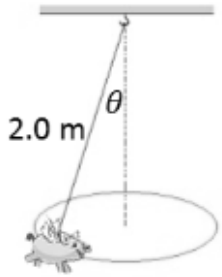
E) The coefficient of kinetic friction must be at least $\frac{v^2}{2rg}$

13. Riders in a carnival ride stand with their backs against the wall of a circular room. The room is spinning horizontally about an axis through its center at a rate of 20 rev/min when the floor drops so that it no longer provides any support for the riders. The rider does not slide down the wall due to static friction, and the coefficient of static friction between the rider and wall is $\mu = 0.50$. What is the maximum distance between the rider and center of rotation for this to be possible?



A) 3.2 m B) 4.7 m C) 1.3 m D) 0.06 m E) 9.5 m

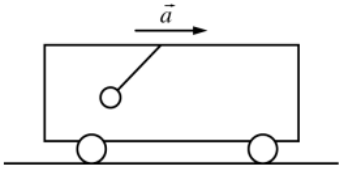
14. A pig of mass 1.0 kg is swung at the end of 2.0 m long string in a conical pendulum as shown. The string makes an angle of $\theta = 20°$ with the vertical. Find the speed of the pig's circular motion before some MSE student breaks it.



A) 3.57 m/s B) 1.56 m/s C) 2.67 m/s

D) 2.43 m/s E) 1.21 m/s

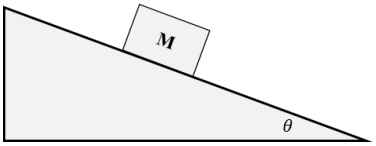
15. A small bob hangs from a string attached to the ceiling of a uniformly accelerating train car. It is observed that the string makes an angle of 40° with respect to the vertical. The magnitude of the acceleration of the train car is most nearly:



A) 12.8 m/s^2 B) 6.3 m/s^2 C) 8.2 m/s^2 D) 7.5 m/s^2 E) 11.7 m/s^2

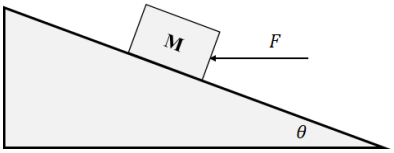
Part 2: Free Response. **You must show all steps** required to arrive at the correct answer for the problem below, including any relevant free body/pseudo free body diagrams. You are graded for your demonstration of physics and problem-solving methods, and not for simply writing the correction answer. A correct answer with no justification will receive no more than one point. All numeric answers must be given with correct units.

16. (12 points) Because this is AP Physics, a block of mass M is on an incline that is angled at θ as shown. The coefficient of static friction on the incline is μ_s and the coefficient of kinetic friction is μ_k.



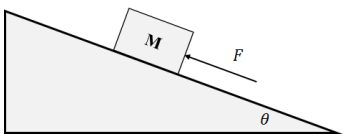
a) The block sets at rest on the incline. Determine an expression for the force of static friction.

b) A force F is now applied parallel to the ground as shown to push the block up the incline.

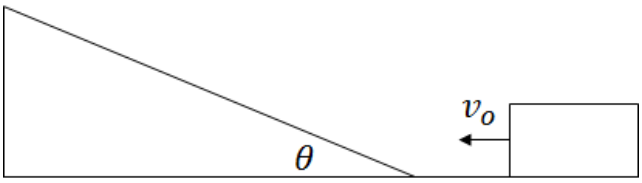


i. Derive an expression for the acceleration of the system if the force F accelerates the mass uphill.

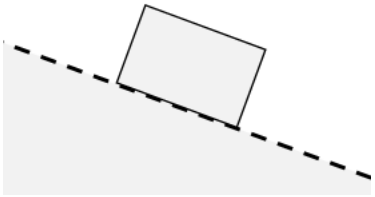
ii. Suppose the force F is now applied parallel to the incline, not parallel to the ground, as shown. Would the acceleration uphill be greater than, less than, or equal to the value from ii). Justify your answer.



17. (14 points) To help curb climate change, it important to reuse resources, so here's the block and incline again. The block of mass M slides along a frictionless surface towards the incline as shown. Once on the incline, the block has a resistive force of bv acting against it.

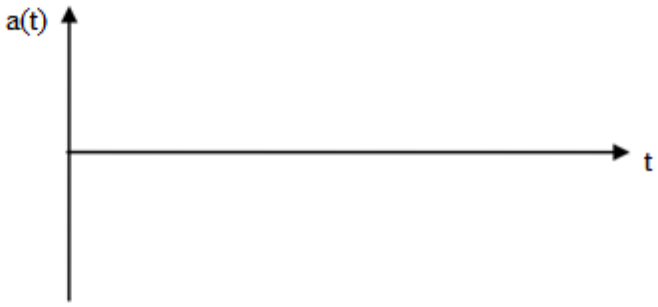


a) On the diagram below, list all forces on the block as it slides up the incline.



b) After going up the incline, the block begins to slide back down with the same resistive force. Derive an expression for the acceleration over time, a(t), as the block slides down the incline.

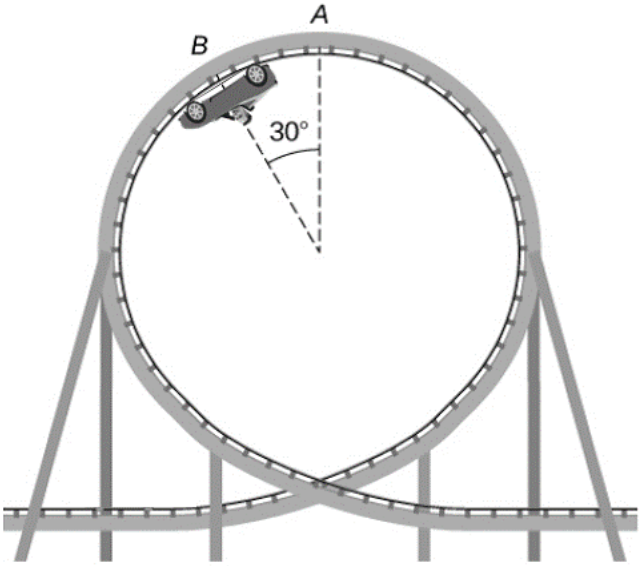
c) On the figures below, plot the velocity and acceleration of the block vs. time as it goes up and down the incline. Label any maxes, mins, and/or asymptotes on the graphs. Take right as the positive direction.



18. (16 points) Tired of all the haters, Elon Musk speeds away in his Tesla to go perform some physics stunts to give relevant scenarios to turn into physics problems, even though no one really asked for his help.

a) First, Elon decides to gain altitude by driving his car in a vertical loop. He drives his car in a vertical circle of radius 20 m. At one point, he is at the top of the circle driving back down. He's car angular displacement from the vertical is 30^o as shown. At this point, he is driving at 24 m/s and Elon Musk has a mass of 75 kg.

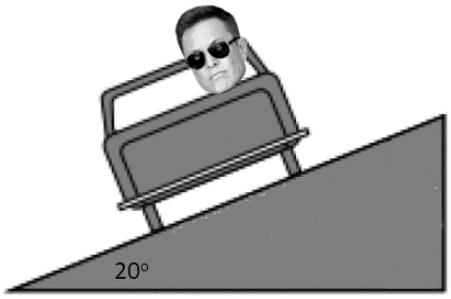
i. Calculate the component of Elon Musk's acceleration at point B that changes his speed.



ii. Calculate the normal force of the car on Elon Musk at point B.

iii. Show that the minimum speed Elon can go at the top of the circle at point A and still maintain circle motion is about 14 m/s.

b) Next, Elon Musk drives on a banked curve with a radius of curvature of 120 m and banked at an angle of 20°. The coefficient of static friction on the incline is .30. What is the maximum speed Elon can drive on the incline and still remain in circular motion?



Bonus (3 points): A truck drives up an incline that is inclined at an angle of $\phi = 30°$ as shown with an acceleration of 8 m/s. A bob of mass $45712\pi\sqrt{13}$ kg on a string in the truck is displaced at an angle of θ. Calculate θ.