Honors Physics Fall Term Recitation Problems

Tips about this packet:

→ Everyone should do every problem!
→ Put your work on the left-hand page. Use the right-right page for notes during presentations
→ Each person will present one problem to the class (approximately 10 minutes) near the end of the term
→ Choosing a problem that looks hard/scary/unfamiliar can allow you to become an expert in that, turning a weakness into a strength
→ The presentations will not be graded, but will be really helpful in preparing for the exam
→ Checking your solutions/answers with me before presentation day is a great idea (you'll only get 10 minutes to present in class, no matter what!)
→ There's no guarantee offered that this covers every piece of every standard from the term, but it's a great place to practice for the exam.

1 A police car is driving towards a parked pair of criminals eating Zagnuts after pulling off a heist. The police car is moving 40 $\frac{m}{s}$ and is initially .4 km away from the criminals. The criminals are going to drive away from the police car in an attempt to escape. Assume that the crimemobile moves with a constant acceleration of 1.8 $\frac{m}{s^2}$.

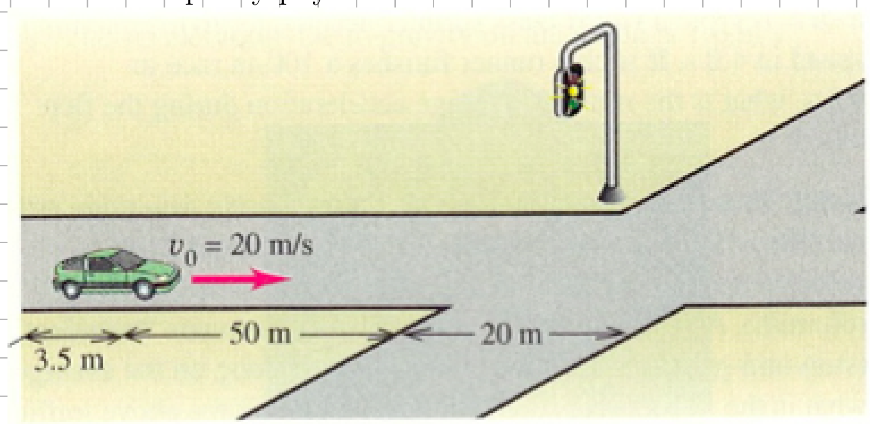
Where will the police catch them?

Draw a velocity graph for the criminals. Use it to determine how far down they road they are when the police car passes their starting point.

Presented by: ________________________

2 A car 3.5 m in length and traveling at a constant speed of 20 $\frac{m}{s}$ is approaching an intersection. The width of the intersection is 20 m. The light turns yellow when the front of the car is 50 m from the beginning of the intersection. If the driver steps on the brake, the car will slow at a rate of 4.2 $\frac{m}{s}$ per second. If the driver instead steps on the gas pedal, the car will accelerate at 1.5 $\frac{m}{s^2}$. The light will be yellow for 3 seconds. Ignore the reaction time of the driver.

To avoid being in the intersection while the light is red, should the driver hit the brake pedal or the gas pedal? Justify your answer with some pretty physics.



Presented by: ______________________

3 A wagon with two boxes of gold (total mass 300 kg) is cut loose from the horses by an outlaw when the wagon is at rest 50 m up a 6 degree slope. The outlaw plans to have the wagon roll down the slope and across the level ground, and then fall into a canyon where his confederates wait.

Find the speed of the wagon when it reaches the flat ground. Note that it starts from rest at the top of the incline and that the wagon rolls with negligible friction.

If another bandit standing at the end of the slope requires twenty seconds to grab the gold, how far must the edge of the cliff be from the end of the slope, in order to make this double-heist successful?

Presented by: ______________________

4 A 20 kg box rests on the flat floor of a truck. The coefficients of friction between the box and floor are $\mu_s = .15$ and $\mu_k = .1$. The truck stops gently at a stop sign and then starts to move with a constant acceleration. The box is 2.2 m from the rear of the truck when the truck starts.

What is the maximum possible acceleration that the truck may have if the box is not to slide?

Suppose that the acceleration of the truck is instead 2.1 $\frac{m}{s^2}$. How much time elapses before the box falls off the rear of the truck?

How far does the truck travel in this time?

Presented by: ____________________

5 A glider is given a quick push to start it moving up a 7° inlined air track. The glider travels to a maximum distance of 112 cm up the track.

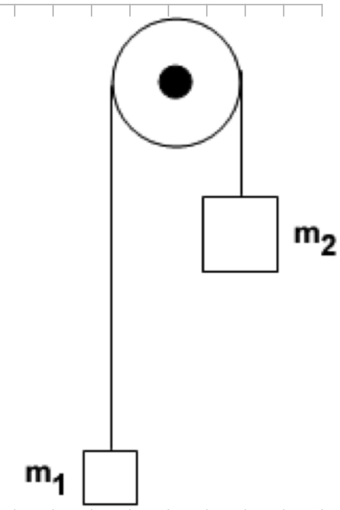
Determine the initial speed of the glider.

Draw a velocity graph for the glider; use the graph to determine how long the glider takes to get to that 112 cm point.

Use your velocity graph to determine where the glider will be 2 seconds after it was launched.

Presented by: ______________________

6 An Atwood machine is constructed from a 3 kg mass and a 1 kg mass. The 3 kg mass is released from rest 180 cm off of the floor, while the 1 kg mass is 40 cm above the floor.



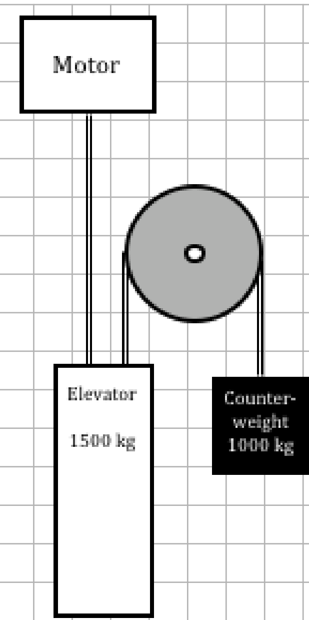
Determine the speed of the 3 kg mass as it hits the floor.

After the 3 kg mass hits the floor, the 1 kg mass will continue to move upwards for a short time. Determine how high above the floor the 1 kg mass will rise.

Draw quantitatively correct acceleration and velocity graphs for the 1 kg mass.

Presented by: ______________________

7 An elevator (1500 kg mass, with passengers) is attached to a 1000 kg counterweight by a cable that is wrapped over a pulley, as shown. It is also attached (by a second cable) to a motor. The elevator is moving down at a constant speed of 5 meters per second.



Determine the force that the motor must apply to the second cable.

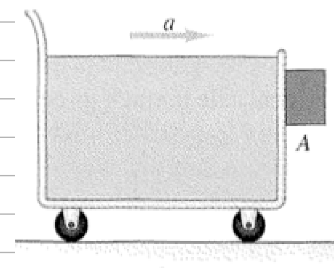
Determine the force that the motor must exert to lower the elevator with a constant downward acceleration of 1 $\frac{m}{s^2}$.

Determine the force that the motor must exert to lower the elevator with a constant upward acceleration of 1 $\frac{m}{s^2}$.

Draw a graph of the acceleration of the elevator as a function of the force exerted by the motor. Fill in important numbers on each axis.

Presented by: ____________________

8 The cart accelerates to the right, keeping block A from sliding down. The coefficient of static friction between the block and the cart is .8, and the coefficient of kinetic friction is .5. The block is 1.2 meters above the ground.

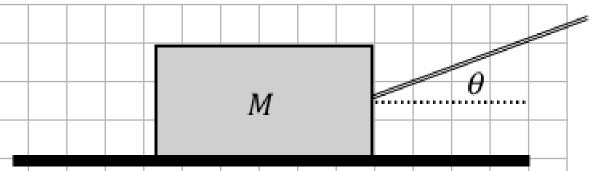


What minimum acceleration must the cart have in order that block A does not fall?

If the acceleration of the cart were only half that value, how long would it take for the block to hit the ground?

Presented by: ______________________

9 A 10 kg box is pulled across the floor by a rope inclined 21° from the horizontal. The coefficient of static friction between the floor and the box is .7 and the coefficient of kinetic friction is .4.

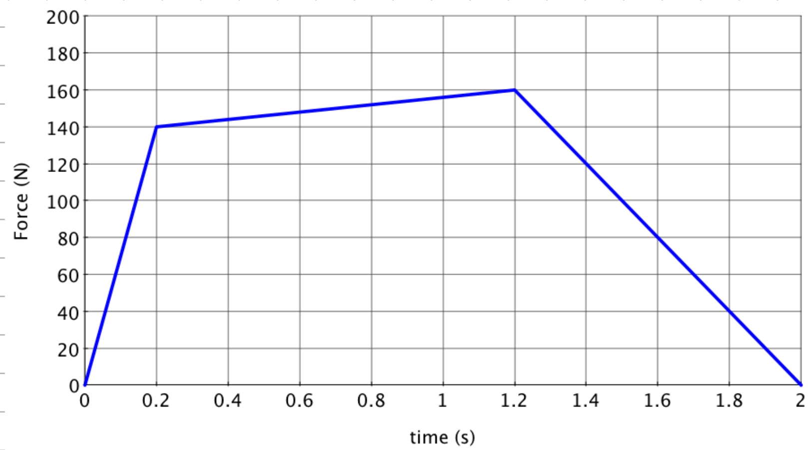


How hard will the rope need to be pulled in order to set the box in motion?

If the angle is changed, the necessary force to make the box slide changes. Determine the angle at which the tension required to move the box is at a minimum. You may need to get creative to find that minimum point!

Presented by: ______________________

10 A 50 kg peewee football player runs into a stationary 40 kg player at an initial speed of 4 meters per second. The magnitude of the force exerted by the football players on each other is shown as a function of time.



Draw quantitatively accurate acceleration graphs for each player.

Use your acceleration graphs to determine the players' final velocities.

Draw a motion diagram showing the players' motions before and after the collision.

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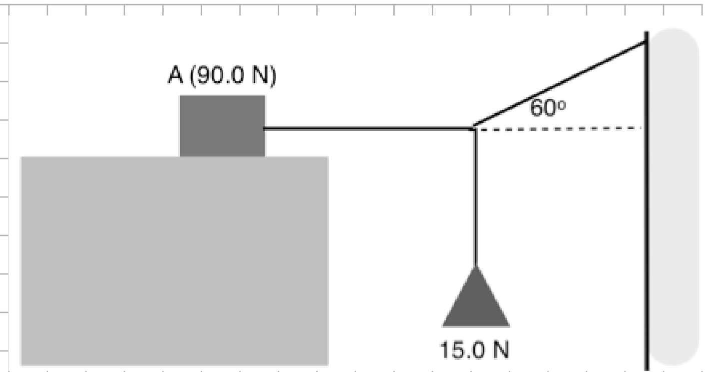
11 In the diagram, there is a block (Block A) with weight 90.0 N resting on the table. The coefficient of static friction between the block and the surface on which it rests is 0.30. Block A is connected to a hanging mass with weight 15.0 N. The hanging mass is also connected to the wall, with the angle of the connecting string being 60 degrees.



Determine the force of friction that must be acting on Block A if the entire system is at rest.

Determine the maximum weight that the hanging mass may have, if all other conditions stay the same.

Presented by: ______________________

CVPM Const. Velocity Particle Model	Core Skills	Identify situations with constant velocity motion from motion maps, graphs, equations, and observation
		Draw a diagram modeling the motion
		Use the definition of velocity to solve simple problems
	Proficiency Indicators	Use the definition of velocity to solve more complex problems
		Differentiate algebraically between average and instantaneous speed and velocity
		Recognize and apply information about special cases of motion (no initial or final v, zero displacement, etc.)
		Differentiate between distance and displacement
	Adv. Ind.	Solve complex (multi-equation system situation) problems

BFPM Balanced Force Particle Model	Core Skills	Recognize when the forces on an object or system are balanced from observation, graphs, equations, or descriptions of the motion
		Identify the presence and directions of normal, tension, and weight forces
		Draw a force diagram (FBD) accurately showing directions and types of forces acting on an object or system
		Write net force equations describing an object or system; they should indicate that the forces are balanced
	Proficiency Indicators	Draw FBD correctly indicating that forces are balanced; recognize same
		Choose and consistently apply workable direction(s) of positive
		Correctly apply Newton's 3rd law
		Choose appropriate axes for force analysis
		Solve problems using net force equations and/or FBD

Friction	Core Skills	Draw an IF chart describing momentum before and after an interaction
		Treat momentum as a vector, correctly and consistently
	Proficiency Indicators	Identify situations in which momentum is conserved
		Write an accurate conservation equation describing the system
		Distinguish among inelastic, completely inelastic, and elastic collisions
		Determine the change in kinetic energy due to a collision
		Analyze elastic collisions using the speeds of approach and retreat
	Advanced Indicators	Analyze collisions using the center-of-mass reference frame

CAPM/G Const. Accel. Particle Model (Graphical)	Core Skills	Translate between velocity and acceleration graphs
		Understand the characteristics of x, v, and a graphs that relate one graph to another
		Recognize characteristic graphical shapes of CAPM motion
	Proficiency Indicators	Convert between position and velocity graphs
		Represent chosen direction of positive correctly and consistently with all graphs
		Recognize and apply information about special cases of motion (no initial or final v, zero displacement, etc.) using graphical models
		Differentiate graphically between instantaneous and average velocity
		Use motion graphs for quantitative problem-solving and motion modeling
	Advanced Indicators	Analyze non-constant acceleration motion using graphs

CAPM Const. Accel. Particle Model	Core Skills	Identify situations with constant acceleration motion from motion maps, graphs, equations, and observation
		Draw a diagram modeling the motion
		Use the definition of acceleration to determine the direction of the acceleration, and to solve simple problems
	Proficiency Indicators	Know and use kinematic equations to solve more complex problems
		Differentiate algebraically between average and instantaneous acceleration
		Recognize and apply information about special cases of motion (no initial or final v, zero displacement, etc.)
		Determine the direction of acceleration from information about the motion
	Adv. Ind.	Solve complex problems

UFPM Unbalanced Force Particle Model	Core Skills	Recognize when the forces on an object or system are not balanced from observation, graphs, equations, or descriptions of the motion
		Identify the presence and directions of normal, tension, and weight forces
		Draw a force diagram (FBD) accurately showing directions and types of forces acting on an object or system
		Write net force equations describing an object or system; they should indicate that the forces are not balanced in the appropriate dimension(s)
	Proficiency Indicators	Draw FBD correctly indicating that forces are not balanced; recognize same
		Choose and consistently apply workable direction(s) of positive
		Correctly apply Newton's 3rd law
		Choose appropriate axes for force analysis
		Solve problems using net force equations and/or FBD

Algebra	Core Skills	Apply percentages accurately and appropriately
		Use no numbers in algebraic manipulations – substitute numbers only when a final expression has been determined (NNTE)
	Proficiency Indicators	Be fluent in algebraic operations
		Recognize the need for an properly apply the quadratic formula
		Use ratios in situations requiring comparison of the same expression

Units	Core Skills	Always state units; know the correct (SI) units for every quantity
	Proficiency Indicators	Check expressions for proper unit cancellation
		Fluently use metric prefixes
		Easily convert units, given conversion factors
		Recognize unreasonable answers
	Adv. Ind.	Use appropriate prefixes for your answers

Vectors	Core Skills	Break a vector into components,along appropriate axes
	Proficiency Indicators	Recognize balanced and unbalanced sets of vectors
		Graphically add and subtract vectors
		Relate initial, final, and change vectors graphically and algebraically
		Use the components of a vector to find the whole vector's magnitude and direction