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Mr. Muehsler Per 3
AP Physics C Semester 1 Project

Kinematics

1) The x and y components of a particle's position are given by the equations below

$P_x = t^2 + 3t$ $P_y = -2t^2 - 1$

What is the magnitude of the particle's velocity at t = 1s if its initial velocity is zero?

a) 6.4 m/s
b) -7.07 m/s
c) -6.4 m/s
d) 7.07 m/s
e) 4 m/s

2) Two cannonballs, where cannonball 1 is heavier than cannonball 2, are shot off the same cliff at the same time with varying initial velocities. Which one will hit the ground first?

a) It depends on their initial horizontal velocities
b) Cannonball 1
c) Cannonball 2
d) Neither Cannonball 1 nor Cannonball 2
e) Cannot be answered with the information given

Forces

3) A student conducts an experiment with a pendulum on Earth and finds that their experimental value of *g* is 9.5 m / s^2. The experiment was conducted on an elevator with constant acceleration. What is the magnitude and direction of the acceleration of the elevator?

	Magnitude	**Direction**
A)	0.3 m / s^2	upwards
B)	-0.3 m / s^2	upwards
C)	0.3 m / s^2	downwards
D)	-0.3 m / s^2	downwards
E)	None of the above	None of the above

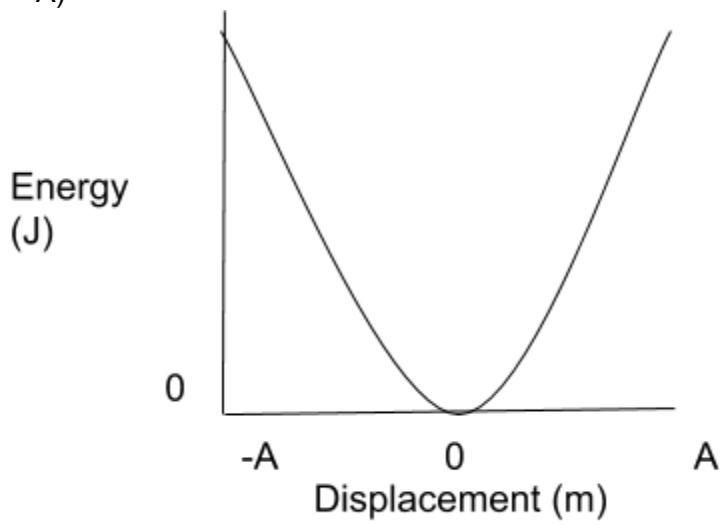
4) A 10 kg object is at rest when it is acted upon by a force of 50N from the right, which of the following best describes the object's resulting motion.

a) 5 m/s to the right
b) 5 m/s^2 to the left
c) 10 m/s to the right
d) 10 m/s^2 to the left
e) 5 m/s^2 to the right

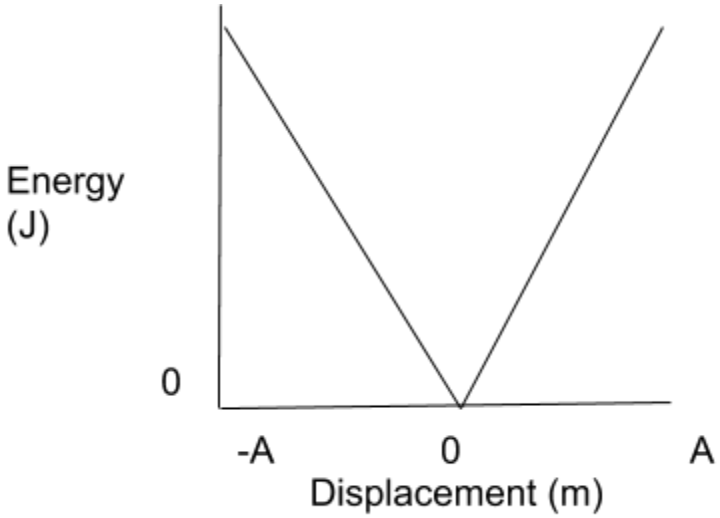
Energy

5) Which of the following potential energy diagrams most accurately represents one of a spring? GRAPHING QUESTION

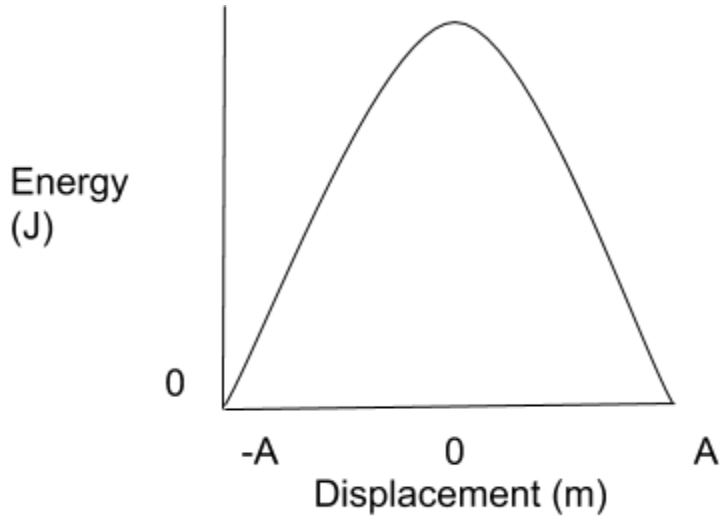
A)



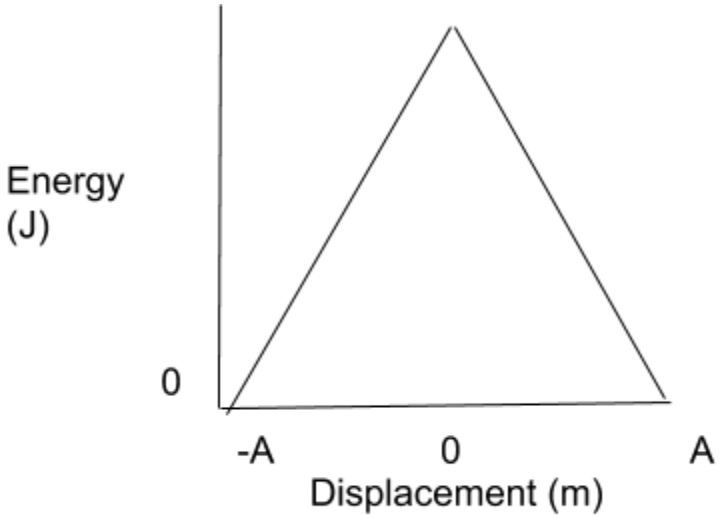
B)



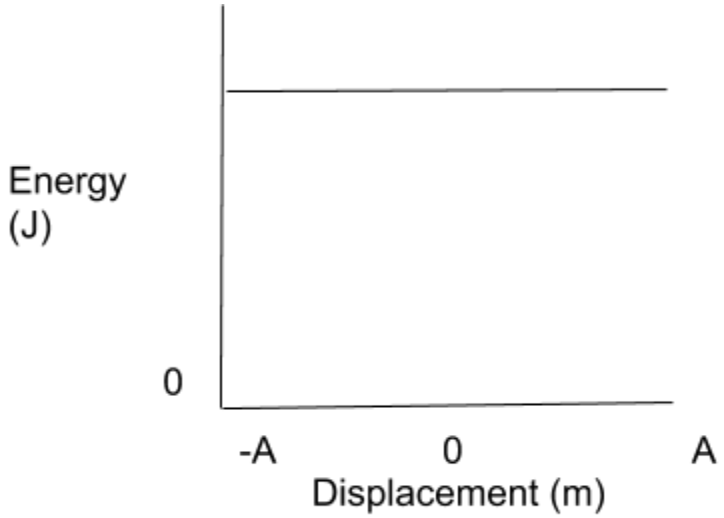
C)



D)



E)

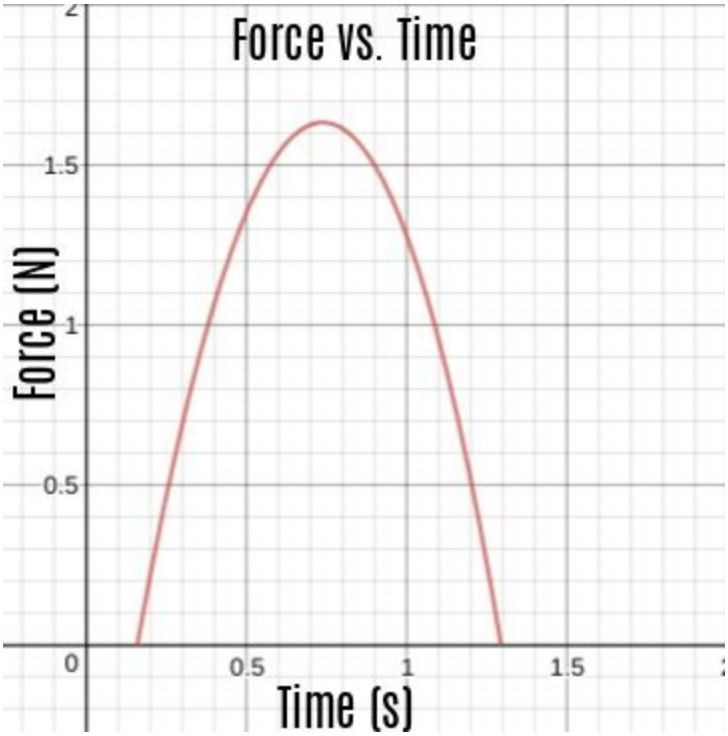


6) A ball is thrown vertically upwards, describe its state of energies at the top of its path.

	Kinetic	Potential	Tot. Mechanical
a)	Maximum	Minimum	Constant
b)	Minimum	Maximum	Constant
c)	Maximum	Maximum	Constant
d)	Minimum	Maximum	Maximum
e)	Minimum	Minimum	Minimum

Momentum

7) A force is applied to an object of mass 4.5kg according to the equation $F = -4t^2 + 8t - e^t$ from the time interval $0.159s \leq t \leq 1.25s$. This force is modeled in the graph below:
GRAPHING QUESTION



On this time interval, what is the change in momentum?

A) 0.261 kg*m / s
B) 1.23 kg*m / s
C) -0.261 kg*m / s
D) -0.123 kg*m / s
E) None of the above

8) An automobile of mass 1000 kg moving at 4 m/s to the right collides with a firetruck of mass 5000 kg moving at 2 m/s to the right. The vehicles stick together. What is their combined speed immediately after the collision.

a) 2.3 m/s
b) 5 m/s
c) 2.8 m/s
d) -2.3 m/s
e) -2.8 m/s

Rotational Motion

9) A thin rod of mass M and length L pivots on an axis at a distance of L/3 from one end. What is the moment of inertia of the rod? Answer in given terms and fundamental constants.

A) ⅓ ML^2
B) 1/12 ML^2
C) 1/9 ML^2
D) 4/9 ML^2

E) ½ ML^2

10) A mechanic is trying to loosen a nut that is attaching two pipes. In order to accomplish this, he has several choices of wrenches to choose from. Assuming the mechanic will exert a force on the wrench perpendicular to to it, which setup would be most effective in loosening the nut?

	Wrench Length	**Force Exerted**
a)	2L	3N
b)	1L	5N
c)	4L	0.5N
d)	3L	3N
e)	8L	1N

Gravitation or SHM

11) A shuttle of mass 1.814 * 10^6 kg is launched from the surface of the Earth. What is the minimum velocity the shuttle must reach to escape the gravitational attraction of the Earth? The mass of the Earth is 5.972 * 10^{24} kg and its radius is 6.371 * 10^6 m.
   A) 1.118 * 10^4 m/s
   B) 2380 m/s
   C) 6.163 * 10^{-6} m/s
   D) 5.95 * 10^4 m/s
   E) 1.036 * 10^4 m/s

12) Planet A is twice as massive as earth but has half the radius. Acceleration due to gravity on this planet would be closest to:
   a) 5 m/s^2
   b) 10 m/s^2
   c) 20 m/s^2
   d) 40 m/s^2
   e) 80 m/s^2

Answers

1) The correct answer is A. This problem tests the students' abilities to recognize velocity as the derivative of position with respect to time and the ability to calculate magnitudes given components. The velocity components can be found by taking the derivative of the position equations, which gives us 2t + 3 and -4t. Now we simply plug in t = 1 into the equations to get the components of 5 in the X direction and -4 in the y-direction. We then sum up the square of these two quantities and square root the result to arrive at the correct magnitude of 6.4 m/s. B and C cannot be the answer because magnitude is a positive value. D cannot be the answer as this is the answer that is yielded when students plug in t = 1 without taking the derivative, which is incorrect as only the derivative of position is velocity.

2) The correct answer is D. This problem tests students' abilities to recognize the conceptual side of kinematics. Because they are falling from the same vertical distance, and F_g acts on the vertical component, acceleration is going to act in the vertical direction and is equal for both cannonballs as this acceleration is equal and not dependent on the mass of the falling object or initial velocity (as initial horizontal velocity does not affect the time it takes for the object to fall because it is constant, which is why A isn't the answer). B and C can't be the answer either because the time it takes for them to fall is dependent on vertical acceleration, which is constant, therefore not dependent on mass, so neither cannonball would arrive first. E isn't the answer as there definitely enough information provided to answer the question. Therefore the answer is D, neither object arrives first, rather they both arrive at the same time.
3) The correct answer is C. This problem tests students' abilities to recognize various forces. The magnitude of the acceleration of the elevator can be found according to the equation $\sum F = mg_{experimental} = mg_{actual} - ma$. The masses will drop out leaving us with the equation $g_{experimental} = g_{actual} - a$. After plugging in the values, we are left with $9.5\ m / s^2 = 9.8\ m / s^2 - a$. Thus, a is $0.3\ m / s^2$. Since the downwards direction has been designated as positive, we know that the elevator is also accelerating downwards. So, the right answer is C. B and D are incorrect since magnitudes cannot be negative. A and E are incorrect since we found that the elevator moves downwards.
4) The correct answer is B. This problem tests students' abilities to recognize F = MA and rearrange it as well as a basic understanding of Newton's 3rd Law. Since a force is applied from the right, the object must accelerate to the left as it is still initially. This eliminates answer choices A, C, E, and D because all of them either have a unit for velocity as opposed to acceleration or have the object going to the right. Therefore, as 500N/10kg is from the right, the object must accelerate at $5\ m/s^2$ to the left.
5) The correct answer is A. This problem tests students' abilities to recognize energy diagrams for a spring. We know that the potential energy equation for a spring is $0.5*k*x^2$. Therefore the equation representing the energy of a spring relative to displacement must be parabolic in nature as the term for displacement is squared whereas 0.5*k is a constant. We can therefore say that B, D, and E are not the correct answers as their graphs aren't parabolic in nature. Furthermore, the equation effectively states that at 0 displacement the potential energy of the spring should be 0. Therefore C can be eliminated as it's graph doesn't reflect this fact. Therefore the answer should be A as it accurately portrays the potential energy of the spring as a function of its displacement.
6) The correct answer is B. This problem tests the students' ability to recognize the energy state of objects at different paths of vertical motion. We know that at the top of an object's path its vertical velocity is zero, so its kinetic energy would be a minimum as per the equation $0.5*m*v^2$. However, it is at its maximum height so it's potential energy would be maximized at the top of its path as per the equation $Energy_{potential} = m*g*h$. Total mechanical energy must always be conserved as the sum of kinetic and potential energy, so choices D and E are incorrect as their total mechanical energies aren't listed as constant. C is incorrect as both PE and KE can't be maximized at the same time at

the top of the path and A is incorrect as it has the correct PE and KE switched in terms of maximization or minimization. Hence the correct answer is B.

7) The correct answer is B. This question tests the students' abilities to recognize that change in momentum is the integral of force with respect to time. This question simply requires one to find the integral of the given force equation, which happens to be $-1.3333*t^3 + 4*t^2 - e^t$. Plugging in our final time and our initial time and subtracting final value from initial value from the other yields us the correct answer. C and D cannot be the answer because the integral (area under the graph) is evidently positive and A cannot be answer because just by observation it appears to be greater than 1. Furthermore, E isn't the answer as B is the definite answer. Therefore our answer is B.
8) The correct answer is A. This question tests the students' understanding of the conservation of momentum. This question requires students to understand that $m_{obj1}*v_{obj1}+m_{obj2}*v_{obj2}=m_{combined/final}*v_{final}$. Plugging in the values yields us $5000*2 + 1000*4 = (5000 + 1000)*v_{final}$. Solving for V_{final} yields us a final combined speed of 2.3 m/s. B is impossible as this velocity is greater than either their initial velocities, which is impossible. D and E aren't possible because the objects are both moving in positive directions so for the final velocity to be negative simply isn't possible. C would be the result of a mathematical error where $m_{combined}$ was set to 5000 as opposed to the combined mass. Therefore, the answer is A.
9) The correct answer is C. This question tests the students' ability to find the moment of inertia of a rod, which is mr^2. Knowing that the axis of rotation of the rod is L/3, we know that this is effectively the radius and using parallel axis theorem we know we can apply this to the equation to yield the correct result of the moment of inertia being this value squared times M. Choices A, B, D, and E fail to implement this equation correctly as they either do not square the quantity for radius or do not take the mass into account at all or add a random constant. This is why the correct answer is C.
10) The correct answer is D. This question tests the students' ability to understand the equation for torque. Torque is r*F*sin(theta), you are simply looking for the combination that maximizes the product of r and F, this answer choice is D as this product is 9, which is greater than any of the other answer choices. A, B, C, and E are incorrect as their values for torque are less than this value of 9 and wouldn't help in the context of the problem as their setup provides less total torque. Therefore, the answer is D.
11) The correct answer is A. This question tests the students' ability to understand the equation for escape velocity.The equation for escape velocity is the square root of $(2*G*M_{earth})/R$. Simply plugging in the correct values would yield you the escape velocity of $1.118 * 10^4$ m/s. The rest of the answer choices are incorrect if they fail to understand that escape velocity the speed one needs to reach in order to somewhat escape the influence of earth's gravity. Using this escape velocity equation incorrectly is what would lead to any of these answers. Therefore the answer is A.
12) The correct answer is E. This question tests the students' understand of the factors that affect the value of acceleration due to gravity. The equation for g is $G*M_{planet}/r^2$. Therefore doubling the mass and squaring the halved radius would result in a value or 4/.5, which is 8. Therefore the acceleration due to gravity on this planet would be 8 times as great as

normal, which is 80. A, B, C, and D aren't possible because they all implement this equation incorrectly. If mass is doubled and radius is halved the only possible change to g is an 8 fold increase. Which is why E is the answer.

https://docs.google.com/document/d/1JsQIpix6fWTsrOXWG8qEAMVSp7hzzfhuU4bTjhYQoO8/edit?usp=sharing
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