Mr. Forrest/ AP Physics C: 2019 Name: _____

Oh, say can you see … the calculus!

Physics-Calculus Problem # 1: From AP Physics book: Chapter 2, #31 on page 65

Concepts: Position, velocity, acceleration

Physics-specific things to remember: Position, velocity, and acceleration relationships

PC1) The position of a particle is given by the function $x = (2t^3 - 9t^2 + 12)$ m, where t is in seconds.

a) At what time or times does the particle reach its turning points?

b) What are the particle's position and its acceleration at this/these time(s)?

c) At what time(s) would the object have no acceleration?

Physics-Calculus Problem # 2: From AP Physics book: Chapter 4, #68, p. 114

Concepts: Angular motion

Physics-specific things to remember: This is similar to linear motion in terms of the relationships between position, velocity and acceleration

PC 2) The angular velocity of a process control motor is $\omega = (20 - \frac{1}{2}t^2)$ rad/s, where t is in seconds.

a) At what time does the motor reverse direction?

b) Through what displacement does the motor turn between $t = 0$ s and the instant it reverses direction?

Physics-Calculus Problem # 3: MODIFIED From AP Physics book: Chapter 6, # 35, p. 162

Concepts: Newton's 2nd Law (a = F/m)

Physics-specific things to remember: To be successful, students will need to take the second derivative of the position function to get the acceleration function, and then apply it to Newton's 2nd Law

PC 3) The position of a 2.0 kg mass is given by $x = (2t^3 - 3t^2)$ m, where t is in seconds.

a) What is the net horizontal force on the mass at (i) $t = 0$ s and (ii) $t = 1$ s?

b) Find the turning point(s) for the mass for $t > 0$ s.

c) Determine the displacement of the object between $t = 0$ s and the first turning point found in (b).

Physics-Calculus Problem # 5: From AP Physics book: Chapter 9, #55, p. 243

Concepts: Impulse and momentum

Physics-specific things to remember: Impulse is the area of a Force vs. time graph. Using the given mass (converted to kg) means that you can find the change in velocity since impulse divided by mass gives the change in velocity. Combined with the initial velocity, you can find the velocity at $t = 2.0$ seconds.

PC 5) A 500 g particle has a velocity $Vx = -5.0$ m/s at $t = -2.0$ s. Force $Fx = (4-t^2)$ N is exerted on the particle between $t = -2.0$ s and $t = 2.0$ s. What is the particle's velocity at $t = 2.0$ s?

Physics-Calculus Problem # 4: MODIFIED From AP Physics book: Chapter 9, #32, p. 241

Concepts: Impulse and momentum

Physics-specific things to remember: Impulse is the area of a Force vs. time graph. The general impulse-momentum formula is: F(dt) = m(dv), which is simply a modification of Newton's 2nd Law, F/m = a

PC 4) A particle of mass *m* is at rest at $t = 0$. Its momentum for $t > 0$ is given by $p_x = 6t^2$ kg*m/s, where *t* is in seconds.

(a) Find an expression for $F_x(t)$, the force exerted on a particle as a function of time.

(b) find the impulse imparted to the mass between $t = 5$ and $t = 10$ seconds.

Physics-Calculus Problem # 7: MODIFIED From AP Physics book: Chapter 11, # 60, p. 306

Concepts: Energy and work

Physics-specific things to remember: Force is the NEGATIVE of the slope of a potential energy vs. position graph, so Fx = -dU/dx. Therefore Ux = -Fx*dx, meaning the potential energy is the negative of the area of a force vs. position graph. For part c), students will need to use the Law of Conservation of energy, so Kei + Ui = Kef + Uf. Only in this case they'll need to use the expression they find in part (b) for U instead of $U = 1/2*k(\Delta x)^2$ for elastic potential energy.

A clever engineer designs a "sprong" that obeys the force law $Fx = -q(x - x_e)^3$, where x_e is the equilibrium position of the end of the sprong and *q* is the sprong constant. For simplicity, let's let $x_e = 0$ m. Then $Fx = -qx^3$.

a) What are the units of *q*?

b) Find an expression for the potential energy of a stretched or compressed sprong.

c) A sprong-loaded toy gun shoot a 20 g Nerf dart during a shootout in senior tag. What is the launch speed if the sprong constant is 40,000, with the units you found in part (a), and the sprong is compressed 10 cm? You may assume the barrel is frictionless.

Physics-Calculus Problem # 10: MODIFIED From AP Physics book: Problem 52, Chapter 30, p. 889

Concepts: Current is the amount of charge flowing per unit time, so $I = dQ/dt$

Physics-specific things to remember: Current is the amount of charge flowing per unit time, so $I = dQ/dt$

PC 10) The total amount of charge in coulombs that has entered a wire at time t is given by the expression $Q = 8t - 2t^2$, where t is in seconds and is for any times at zero or above zero.

a) Find an expression for current in the wire at time t.

b) Graph I vs. t for the interval $0 <= t <= 4$ s.

c) What is happening at 2 seconds?

IDEA for a problem #11 → Could problem #10 be modified with a trig function? That would actually mimic the true pattern of alternating current in our outlets (which has a frequency of 60 cycles/sec)