AP Calculus
Real World Wednesday #3

Name: ______________________________
Date: ______________________ Per: ____

Directions: Read the article associated with the FRQ problem, then on a separate sheet of paper (folded in half: a,b on front; c, d on back similar to the AP test) complete the FRQ. * indicated calculator active.

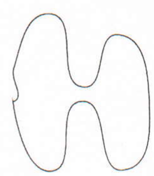
Volume 1-25: From The Altoona Mirror: 4/7/13 *calculator allowed

Sinking of the Thresher

It was probably a small hole that killed the 129 crew members and civilians aboard the Thresher in 1963, the most advanced attack submarine of its day. There had been problems with silver-braze welds in pipes on the craft, but they hadn't been considered overly serious. However, when the Thresher was deep in the ocean, past the continental shelf, off Cape Cod that morning, one of those welds in a seawater piping system may have given way. "Seawater piping system" means the water inside the pipes was under the ambient pressure of the ocean. The hole was probably 2 to 5 inches wide, according to a Navy report declassified in 1993. A much smaller hole, just a quarter-inch wide, 400 feet below the surface would jet like a fire hose, the article stated. A 1-inch hole - still smaller than the one presumed to have caused the disaster - at that depth would be "something beyond the imagination of most of us," according to Vice Adm. E.W. Grenfell. It was "cut-you-in-two pressure," said Kevin Galeaz, former nuclear submariner. Based on informed speculation and probability, the stream from the leak shorted out an electrical panel that controlled the nuclear reactor that powered the sub. The electrical shutdown triggered an automatic shutdown of the nuclear plant, leaving the sub without means of propulsion, if the operator followed prescribed procedures and cut off residual steam to the turbines that powered the sub, so as not to cool the reactor too quickly, according to the article. That would have left the captain without the means to surface normally, by driving the craft upward using its dive planes. Instead, he would have needed to blow the ballast tanks. But shortly after sending compressed air into those tanks, the airflow slowed or stopped, probably because ice formed in debris strainers and the submarine eventually sank past the classified maximum depth the hull could withstand.

The problem below revolves around water rushing in through a hole in a boat.

A plate bursts on a ship and water rushes in. The hole's shape is shown on the right and has height measurements according to the table. The velocity of the water flowing through the hole in inches per minutes is modeled by $v(t) = 15 + 3\sin(0.2t - 30)$ for $0 \le t \le 60$ seconds.



Distance from the left bottom of hole (inches)	Height of hole (inches)
0	1
1	4.5
2	0.5
3	4
4	0

a) Use a trapezoidal sum with four intervals indicated by the data in the table to approximate the area of the hole in square inches. Show the computations that lead to your answer.

*b) The volumetric flow of the water through the hole in the product of the area of the hole and the velocity of the water. Use your approximation from part a) to estimate the average value of the volumetric flow of the water through the hole, in cubic inches per second, from $t = 0$ to $t = 60$ seconds.

c) An engineer gives the function *f*, given by $f(x) = -x^4 + 8x^3 - 20x^2 + 16x + 1$ as a model for the height of the hole, for $0 \le x \le 4$, x measured in inches. Find the area of the hole.

*d) Emergency pumps will turn on once at least 6 cubic feet of water that have poured in. Using the function in part c), write, but do not solve, an equation that will determine the time k when the emergency pumps turn on.

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CALCULUS: RIPPED
FROM THE HEADLINES

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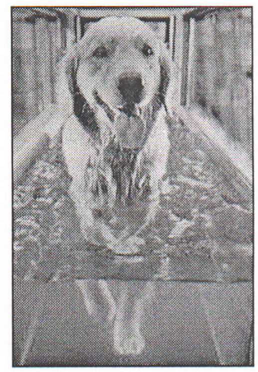
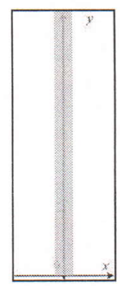
Volume 1-18: Hemel Today 4/12/13 *calculator allowed

Dogs and Water Do Mix



Mark Mayho, owner of Herts Canine in Gadebridge, runs a hydrotherapy pool for dogs. The hydrotherapy pool was installed six years ago, and is recommended by most vets in Hemel Hempstead, and Mark has also had dogs in the pool to exercise and build muscle tone before being shown at the world's best-known dog show. Energetic Rolo is a five-year-old chocolate labrador who lives with her owners in Boxmoor. She has been coming to Mark for four years, as using the pool works on her fitness and burns off her boundless energy. Her younger sister Queenie, 3, is also a regular visitor and sometimes comes in twice a week for a session. Mark says that most dogs don't like getting in the hydrotherapy pool for the first time, but once they get used to it they look forward to sessions, as demonstrated by Rolo. He said: "Initially we get them to do three sets of two minutes, building it up by 30 seconds each time, until we get most dogs doing two sets of eight minutes." Dogs love swimming so hydrotherapy can be a fun but vital part of a fitness or rehabilitation regime following illness, injury or surgery. Dogs get a great workout in the water as most of the muscles usually used in movement are involved when swimming and dogs who don't take to swimming can walk along a treadmill installed on the bottom of the pool. The water also has added benefits when treating dogs suffering from arthritis or obesity as the buoyancy of the water helps avoid the pressures of normal weight bearing on the limbs and joints. Hydrotherapy is a great all round workout for your dog as it benefits the heart and lungs as well as improving muscle strength and joint mobility.

The problem below revolves around a dog walking in a hydrotherapy pool.



Chessie the dog is placed in a hydrotherapy pool in which there is a treadmill on the bottom. The pool is modeled after the Cartesian plane with the treadmill on the y-axis as shown in the figure to the right. Chessie is placed in the pool on the treadmill and at time $t = 0$ the treadmill begins to move and Chessie begins to walk. Chessie walks for π minutes and her position along the treadmill is given by $y(t) = -300e^{-t}(\cos t - 1)$, where y is measured in feet.

*a) Find the maximum distance Chessie is from her initial position when the treadmill started. Justify your answer.

b) How far does Chessie walk for $0 \le t \le \pi$? Explain.

c) Was Chessie slowing down or speeding up at $t = \dfrac{3\pi}{4}$? Show how you reach your conclusion.

d) Write, but do not solve, the equation that determines the time $0 \le t \le \pi$ when Chessie has the greatest acceleration.

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