A CONVERSATION WITH ERIC MAZUR

Using the 'Beauties of Physics' to Conquer Science Illiteracy

By CLAUDIA DREIFUS
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CAMBRIDGE, Mass. — In the halls of academia, it is the rare senior professor who volunteers to teach basic science courses to undergraduates.

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Jodi Hilton for The New York Times
Eric Mazur

But Eric Mazur, the Gordon McKay Professor of Applied Physics at Harvard, is driven by a passion. He wants to end science illiteracy among the nation's college students; specifically, he strives to open them to the "great beauties of physics."

Mazur's own Harvard course, Physics 1b, is the kind of science class that even a literature student might love — playful, engaging, something like a trip to a science museum. Indeed, Dr. Mazur, 52, is as experimental in his classroom as he is in his research laboratory.

"It's important to mentally engage students in what you're teaching," he explains. "We're

Caution: Careful probing needed!

- It is ***very easy*** to overestimate students' level of understanding.
- Students ***frequently*** give correct responses based on incorrect reasoning.
- Students' written explanations of their reasoning are powerful diagnostic tools.
- Interviews with students tend to be profoundly revealing … and extremely surprising (and disappointing!) to instructors.

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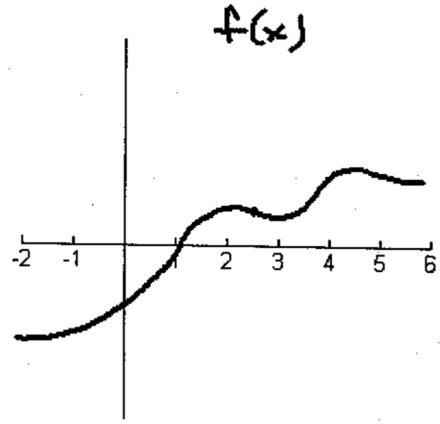
Presenting the concept questions

- **Every 10 or 15 minutes**
- **Each student votes in silence**
- **Students discuss votes on groups**
- **Each student votes again**
- **Whole class discussion**

The graph of f(x) is shown below.



$$\int_{-2}^{6} |f(x)|\,dx =$$

a. $\left| \int_{-2}^{6} f(x)\,dx \right|$

b. $\int_{-2}^{0} |f(x)|\,dx + \int_{0}^{6} |f(x)|\,dx$

c. $\int_{-2}^{1} f(x)\,dx + \int_{1}^{6} -f(x)\,dx$

d. $\int_{-2}^{1} -f(x)\,dx + \int_{1}^{6} f(x)\,dx$

more than one answer ok

A function is continuous on [a,b] but not everywhere differentiable on (a,b).

$f(a) = f(b)$

Which of the following is a true statement?

a. **f must have a horizontal tangent line on (a,b)**

b. **f might have a horizontal tangent line on (a,b)**

c. **f can't have a horizontal tangent line on (a,b)**

$$f(x) = 4x^5 - 6x^2 - 2x + 19$$

Which of the following statements are true?

a. f(x) has an absolute maximum.

b. f(x) has an absolute minimum.

c. f(x) has at least one zero.

d. f(x) is decreasing at x = 0.

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$f(x)$ is a continuous function with the following derivative:

$$f'(x) = \left(x^4 + e^{-x^2}\right)^8$$

The absolute minimum of $f(x)$ on the interval $[-1, 4]$ must occur

a. at $x = -1$

b. at $x = 4$

c. at $x = 0$

d. at a critical point between -1 and 4

A curve has a horizontal tangent line at $P=(0,2)$.

Its second derivative, $\frac{d^2y}{dx^2}$, is equal to $\frac{2y - 2x \cdot \frac{dy}{dx}}{(y+x)^2}$.

At P, the curve has

a. no relative extrema

b. a relative maximum

c. a relative minimum

For a function $f(x)$, $f'(1) = 2$ and $f''(1) = -5$.

Which of the following statement(s) is/ are true?

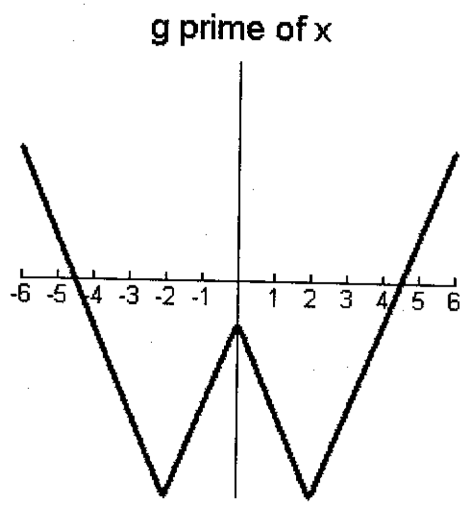
a. **$f(x)$ has a relative maximum at $x = 1$.**

b. **$f(x)$ has a relative minimum at $x = 1$.**

c. **There is no relative extrema at $x = 1$.**

d. **The second derivative test does not apply at $x = 1$.**

The graph of $g'(x)$ is shown below.



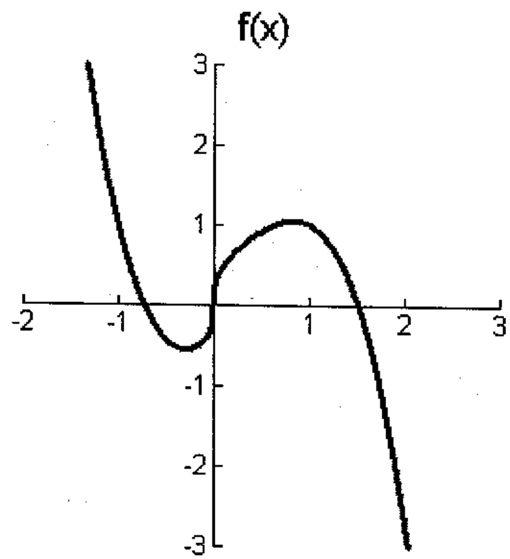
The graph of g must have

a. One local maximum and two local minimum

b. One local maximum and one local minimum

c. Two local maximum and one local minimum

How many critical points does f(x) appear to have?



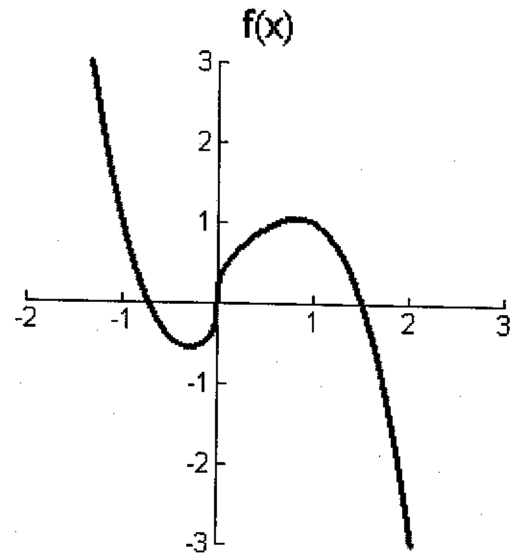
a. none

b. 1

c. 2

d. 3

How many inflection points does f(x) appear to have?

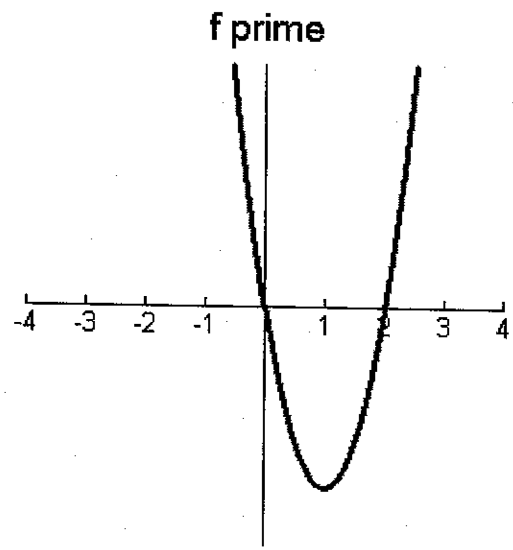


a. none

b. 1

c. 2

d. 3



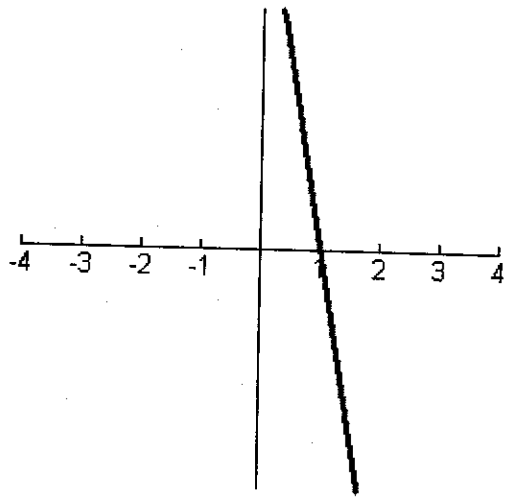
For what values of x is f concave up?

a. **all real numbers**

b. **$(1,\infty)$**

c. **$(-\infty,0)\cup(2,\infty)$**

f double prime



For what values of x is f concave down?

a. no values of x

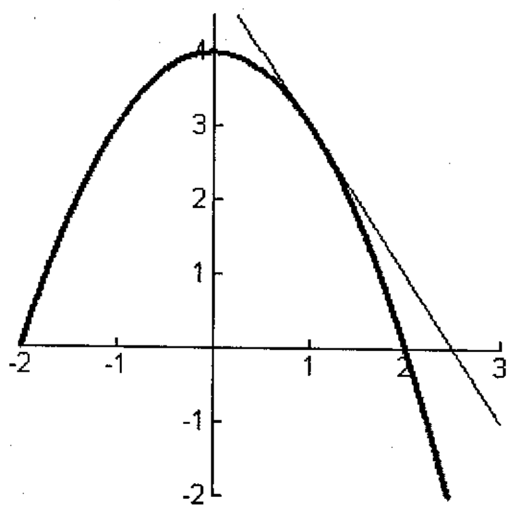
b. all reals

c. $(1,\infty)$

d. $(-\infty,1)$

The graph of $f(x)=4-x^2$ and its tangent line at $x=1$ are shown below.

The equation of the tangent line is $y=-2(x-1)+3$.



Determine an estimate for $4-1.001^2$ and whether this is an overestimate or underestimate.

a. 3.002 underestimate

b. 3.002 overestimate

c. 2.998 underestimate

d. 2.998 overestimate

If $y = f(x)$, then $\frac{d}{dx}\left(y^4\right) =$

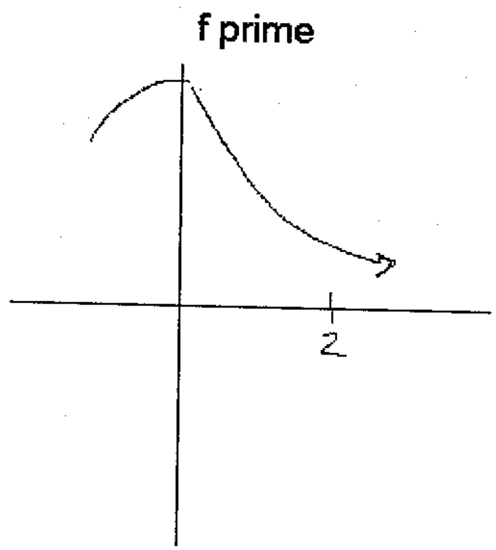
a. $4y^3$

b. $4y^3 \cdot \frac{dy}{dx}$

c. $\frac{y^5}{5}$

d. $4y^3 + C$

Which of the following statements are true?



a. On [0,2] $f'(x) > 0$

b. On [0,2] $f'(x)$ is decreasing.

c. On [0,2] f(x) is concave up.

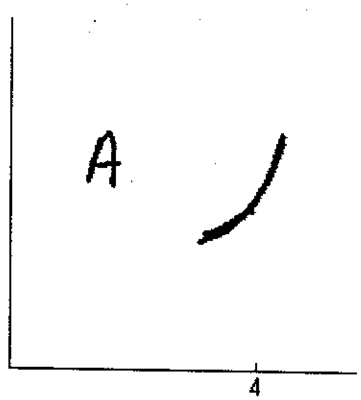
d. On [0,2] f(x) is decreasing.

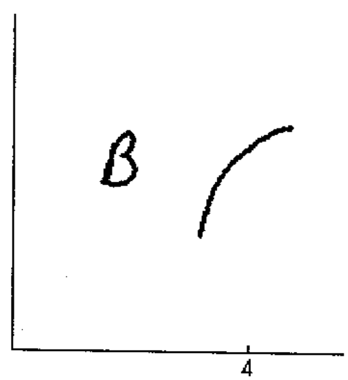
For a function f(x),

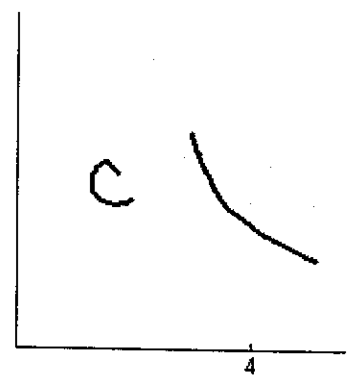
$$f'(x) = (x-5)(x+1)$$

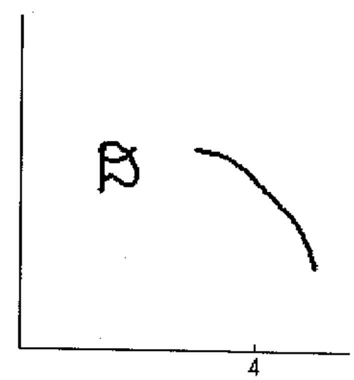
$$f''(x) = 2x-4$$

Which of the following graphs best shows the function's behavior near x =4?









What is the meaning of the statement $\int_2^3 g'(x)\,dx = 5$?

a. $g(3) = 5$ and $g(2) = 0$

b. $g(3)$ is 5 units more than $g(2)$.

c. At $x = 3$, $g(x)$ is 5 times steeper than it is at $x = 2$.

You start to drink from a full glass of water.

Let $V(t)$ be the volume of water in the glass at time t.

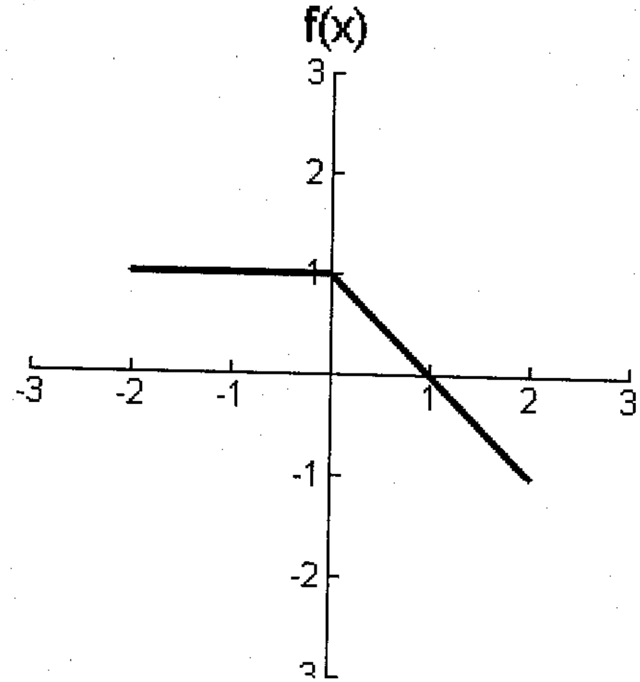
$V(t)$ is measured in ml. and t is measured in sec.

The units for $V'(t)$ and $\int_0^4 V'(t)\,dt$ are:

a. $V'(t)$: ml./sec $\quad \int_0^4 V'(t)\,dt$: ml./sec

b. $V'(t)$: ml. $\quad \int_0^4 V'(t)\,dt$: ml./sec

c. $V'(t)$: ml./sec $\quad \int_0^4 V'(t)\,dt$: ml.

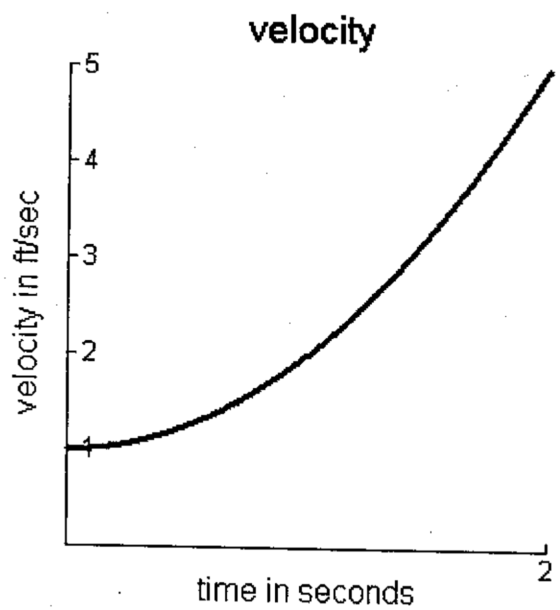


$$\int_{-2}^{2} f(x)\,dx =$$

a. **1** *b.* **2** *c.* **2.5** *d.* **3**

A particle moves along a horizontal line.

Its velocity function is shown below.



The distance traveled on [0,2] is

a. between 1 ft/sec and 5 ft/sec

b. between 2 ft/sec and 10 ft/sec

c. between 1 ft and 5 ft

d. between 2 ft and 10 ft