



LON-CAPA

Mathematical Functionality

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May 2011

LON-CAPA Mathematics

- Mathematics Output:

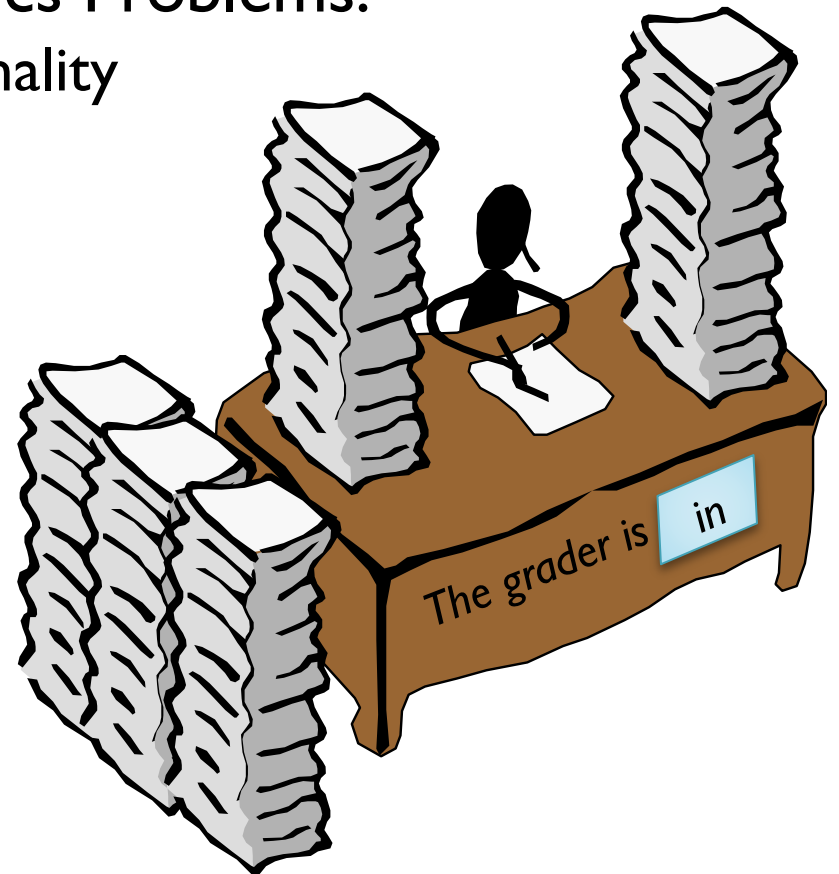
- typesetting
- graphing

- Generating Mathematics Problems:

- symbolic math functionality
- statistics packages

- Mathematics Input:

- numerical
- formula evaluation
 - sampling
 - symbolically
 - checking for properties
- graphical input
- bubble sheets
- clickers




WARNING

Today's presentation is going to show some very specialized functionality. Because you can does not mean you have to.



Mathematical Output

- **Typesetting:**
LaTeX can be embedded anywhere in the material

Text Block Delete? Edit Math  [Greek Symbols !\[\]\(9aae4ef11f04080694e1bcd3250dc654_img.jpg\)](#)

[Rich formatting »](#)

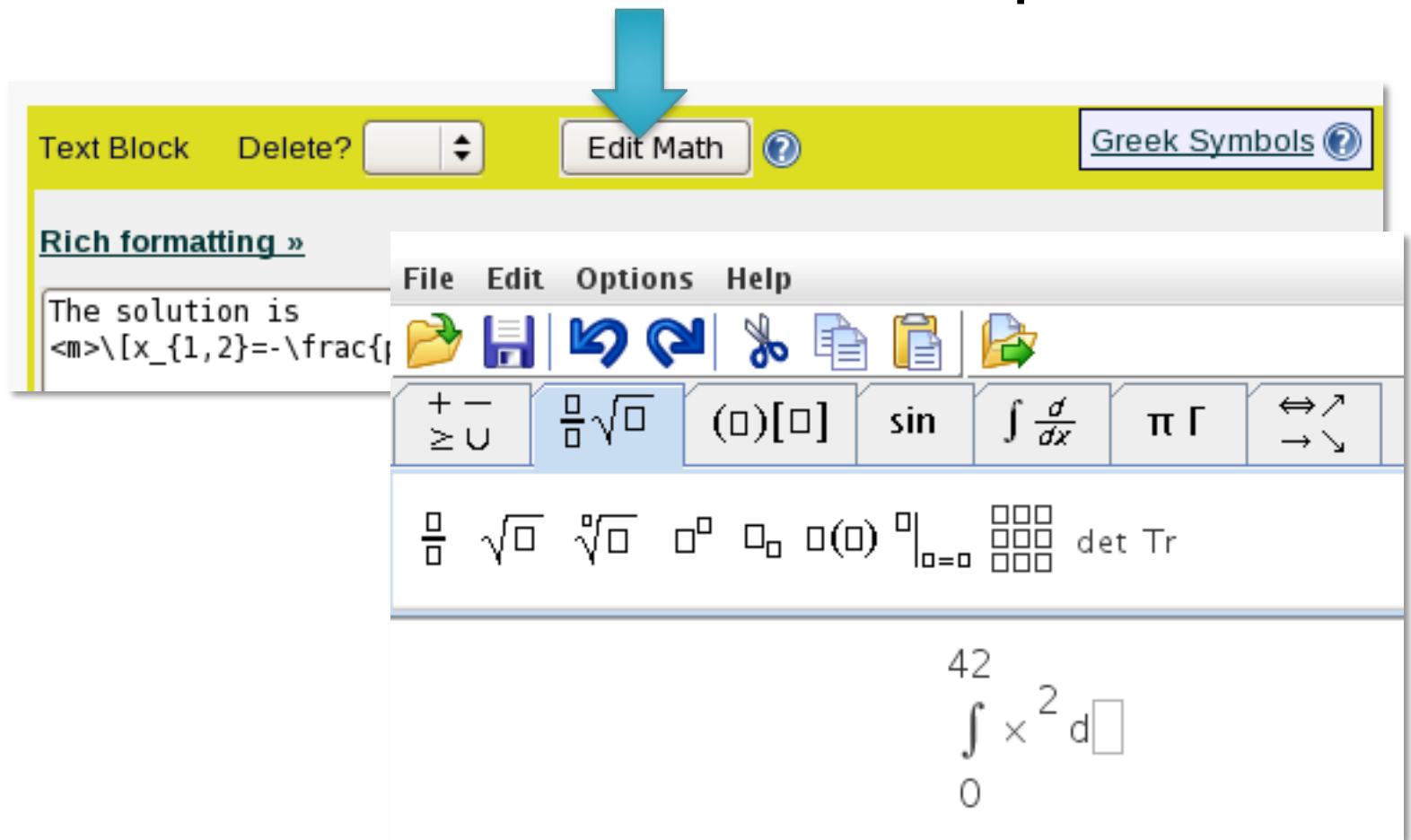
The solution is
<m>\[x_{1,2}=-\frac{p}{2}\pm\sqrt{\left(\frac{p}{2}\right)^2-q}\]</m>

The solution is

$$x_{1,2} = -\frac{p}{2} \pm \sqrt{\left(\frac{p}{2}\right)^2 - q}$$

Mathematical Output

- Editor for non-native LaTeX speakers



The screenshot displays a software interface for editing mathematical content. At the top, a yellow toolbar contains a 'Text Block' dropdown, a 'Delete?' button, an 'Edit Math' button (highlighted with a blue arrow), and a 'Greek Symbols' button. Below the toolbar, a 'Rich formatting »' section is visible. The main editor area shows the text 'The solution is' followed by a LaTeX code snippet: $\langle m \rangle \{x_{1,2}\} = -\frac{\{ \dots \}}{\{ \dots \}}$. A floating toolbar is positioned over the editor, featuring a menu bar with 'File', 'Edit', 'Options', and 'Help'. The toolbar includes icons for file operations (save, open, copy, paste) and mathematical symbols such as $\frac{\square}{\square}$, $\sqrt{\square}$, $(\square)[\square]$, \sin , $\int \frac{d}{dx}$, π , Γ , and arrows. Below these icons, a row of mathematical symbols is displayed: $\frac{\square}{\square}$, $\sqrt{\square}$, $\sqrt[\square]{\square}$, \square^\square , \square_\square , $\square(\square)$, $\square|_{\square=\square}$, a 3x3 grid of squares, and 'det Tr'. At the bottom of the editor, a mathematical expression is shown:
$$\int_0^{42} x^2 dx$$

Mathematical Output

- Generated on-the-fly, can vary from student to student.

Script Delete?

```
$k=&random(2,5,1)
```

Insert:

Text Block Delete? Edit Math

[Rich formatting »](#)

```
What is the derivative of  
<m eval="on">\[\frac{1}{$k}x^{k}\]</m>  
with respect to <m>$x$</m>?
```

What is the derivative of

$$\frac{1}{3}x^3$$

with respect to x ?


What is the derivative of

$$\frac{1}{5}x^5$$

with respect to x ?

Mathematical Output

- `<algebra>`-tag to pretty-print the output from computer algebra systems
- Example: `$formula="a*x^5"`

Text Block Delete? Edit Math 

[Rich formatting »](#)

What is the derivative of `<algebra>$formula</algebra>` with respect to x?

What is the derivative of $a \cdot x^5$ with respect to x?

Tries 0

Mathematical Output

- One-source, multiple target
- Looks good in print

- Online:

The solution is

$$x_{1,2} = -\frac{p}{2} \pm \sqrt{\left(\frac{p}{2}\right)^2 - q}$$

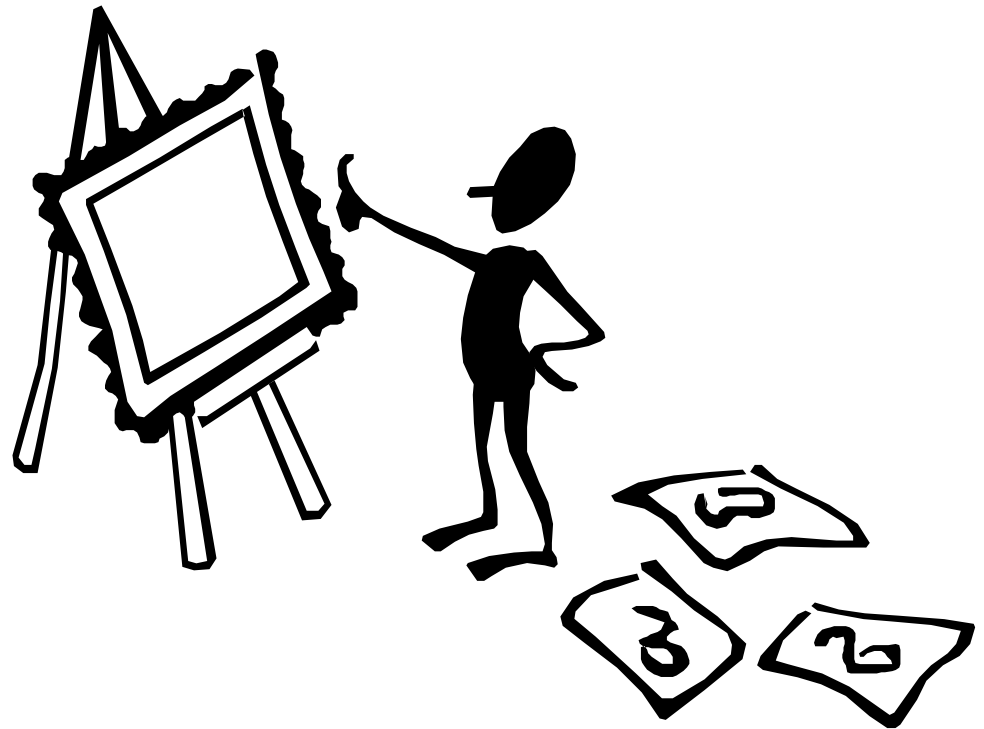
- Print (dynamically generated PDF):

The solution is

$$x_{1,2} = -\frac{p}{2} \pm \sqrt{\left(\frac{p}{2}\right)^2 - q}$$

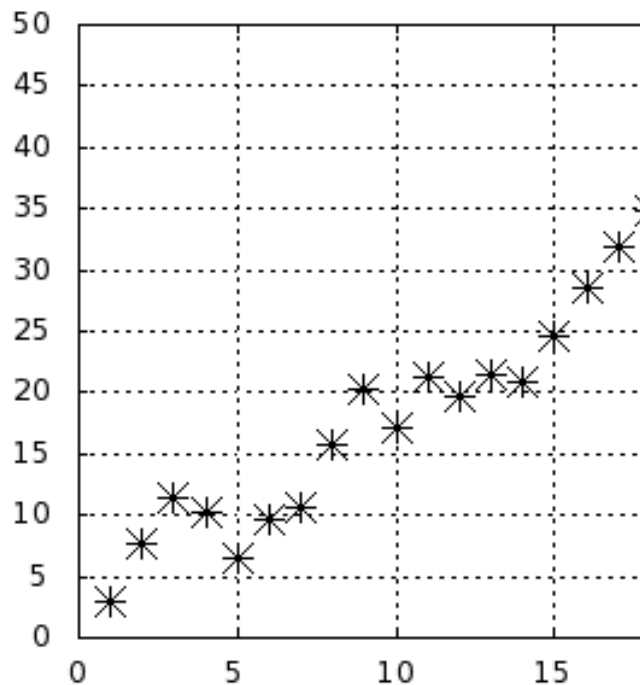
Mathematical Output

- Dynamic Graphing
 - Data-Points
 - Functions
 - Line-Graphics
- Internally uses GNUplot



Mathematical Output

- Data points



Curve Delete?

Color of curve (x000000)

Name of curve to appear in key

Plot with:

Line width (may not apply to all plot styles)

Line type (may not apply to all plot styles)

Point type (may not apply to all plot styles)

Point size (may not apply to all plot styles)

Point to fill -- for filledcurves

Comma or space delimited curve data

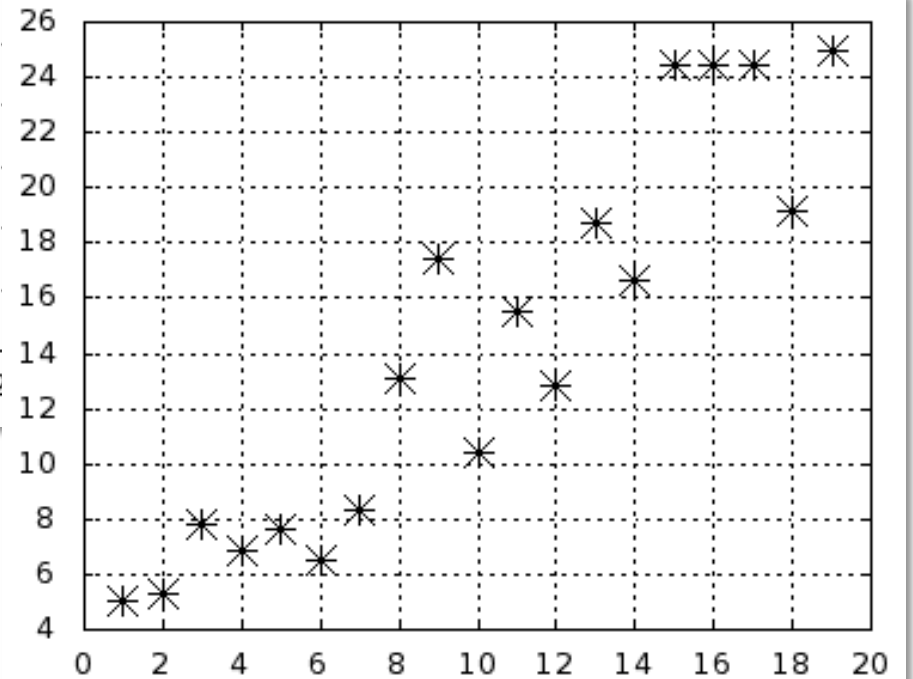
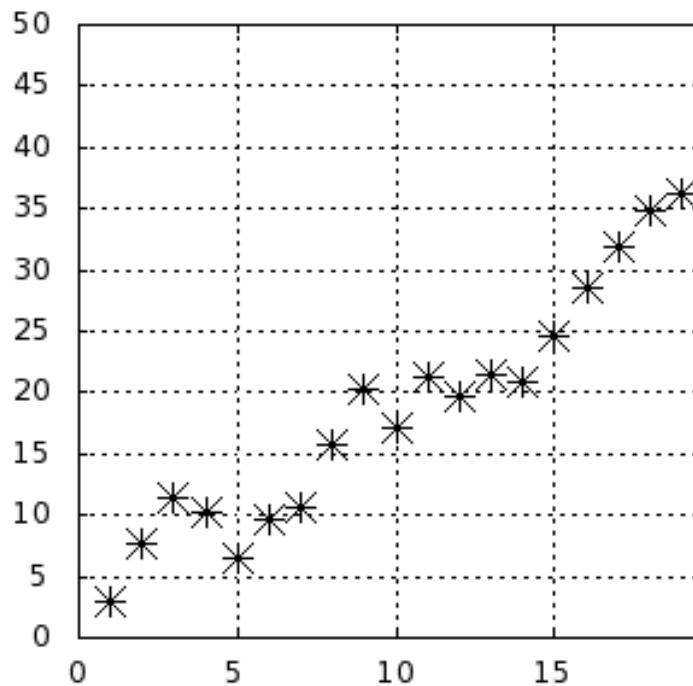
Insert:

Comma or space delimited curve data

Insert:

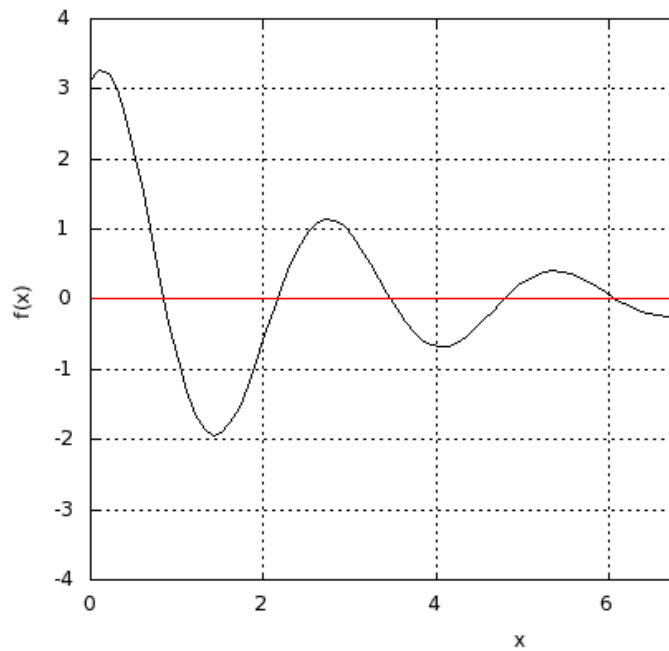
Mathematical Output

- Data points



Mathematical Output

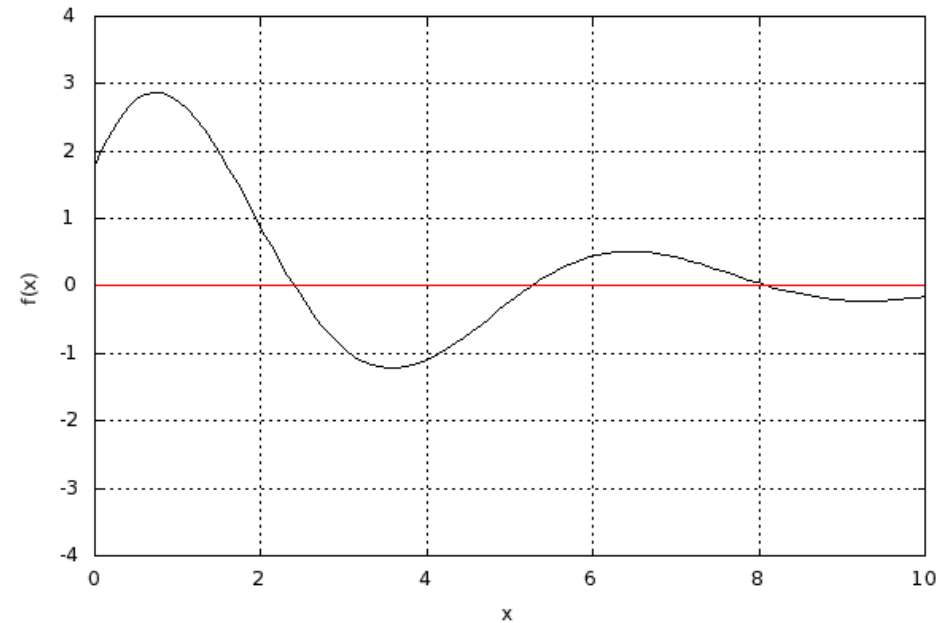
- Functions



Match the function indicated in black.

$f(x) =$

Tries 0/99



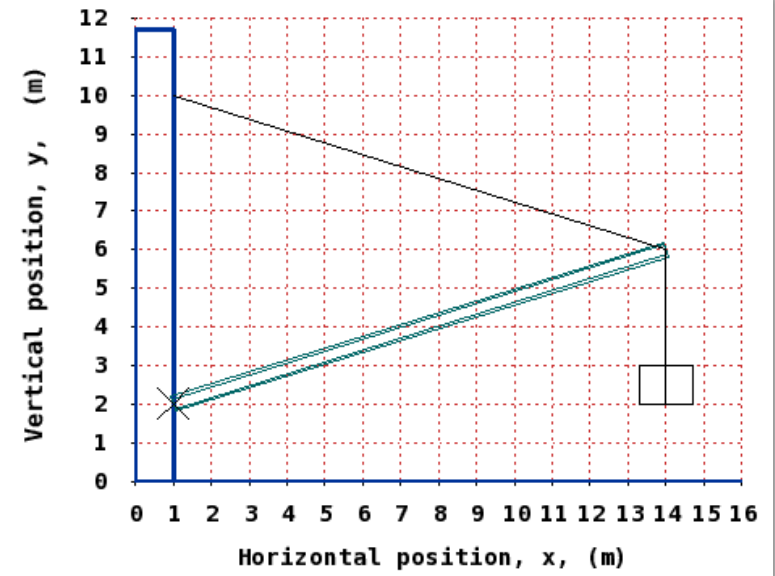
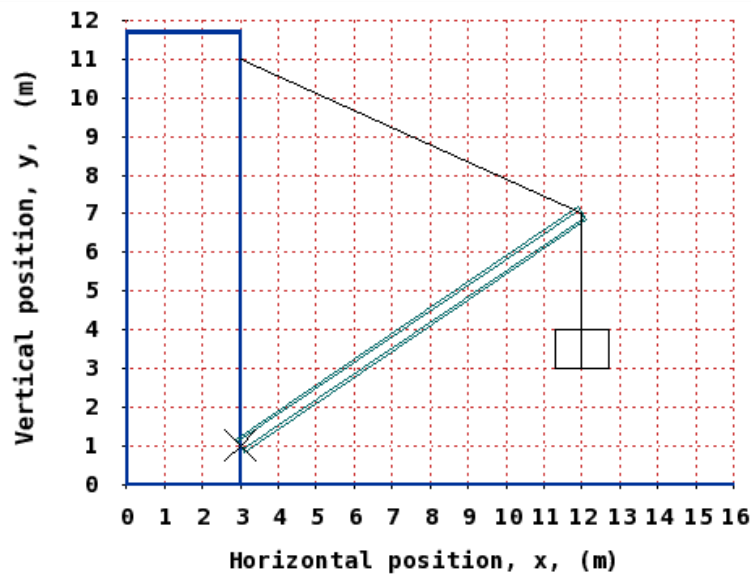
Match the function indicated in black.

$f(x) =$

Tries 0/99

Mathematical Output

- Line graphics



Generating Mathematics Problems

- LON-CAPA problems include
 - Perl Scripting Environment
 - MAXIMA Computer Algebra System
 - R Statistics Package
- Problems not just randomized, but randomly generated with desired properties

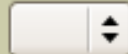


Generating Mathematics Problems

- Direct calls to MAXIMA:
`$result=&cas('maxima',$expression);`
- Simple example: use computer algebra system to calculate a reduced fraction

Script

Delete?



```
# Construct an Egyptian Fraction that can be represented by three terms with denominators between 3 and 12
@denominators=(&random_permutation(&random(1,1000,1), (3..12)))[0..2];
$egyptian='1/' . (join('+1/', sort{$a<=>$b}(@denominators)));
$possible="A possible solution is $egyptian";

# Let the CAS figure out the value
$solution=&cas('maxima',$egyptian);
```

Write 103/165 as an Egyptian Fraction

Submit Answer

Tries 0

Answer for Part: 0

A possible solution is $1/3+1/5+1/11$

Generating Mathematics Problems

- Direct calls to R:
`$result=&cas('R',$expression);`
`$results=&cas_hashref('R',$expression);`
- Example: generate a distribution with certain properties:

Script

Delete?



```
$seed=&random(1,500,1);  
$n=&random(15,25,1);  
$offset=&random(2,5,0.1);  
$slope=&random(0.6,2.5,0.1);  
# construct a data set using R  
# dump is for debugging, print to screen to see data structure  
($data,$dump)=&cas_hashref('R',"set.seed($seed);x<-1:$n;w<-1+sqrt(x)/2;data.frame(x=x,y=$offset+$slope*x+rnorm(x)*w);");  
@x=&cas_hashref_array($data,'x');  
@y=&cas_hashref_array($data,'y');
```


Mathematics Input

Script

```
$vx=&random(3,6,0.1);
$vy=&random(2,8,0.1);
$vz=&random(4,10,0.1);
$t=&random(4,9,1);
@solution=($vx*$t,$vy*$t,$vz*$t);
```

Insert:

Text Block

Rich formatting »

An object starts at the origin with a constant velocity of

```
<m eval="on">
\[\vec{v}=\left(\begin{array}{c}$vx\\ $vy\\ $vz\end{array}\right)\right)
\frac{\mbox{m}}{\mbox{s}}\]
</m>
```

Where is it \$t seconds later?

[Check Spelling](#)

Insert:

Response: Numerical

Answer: Incorrect Answers:

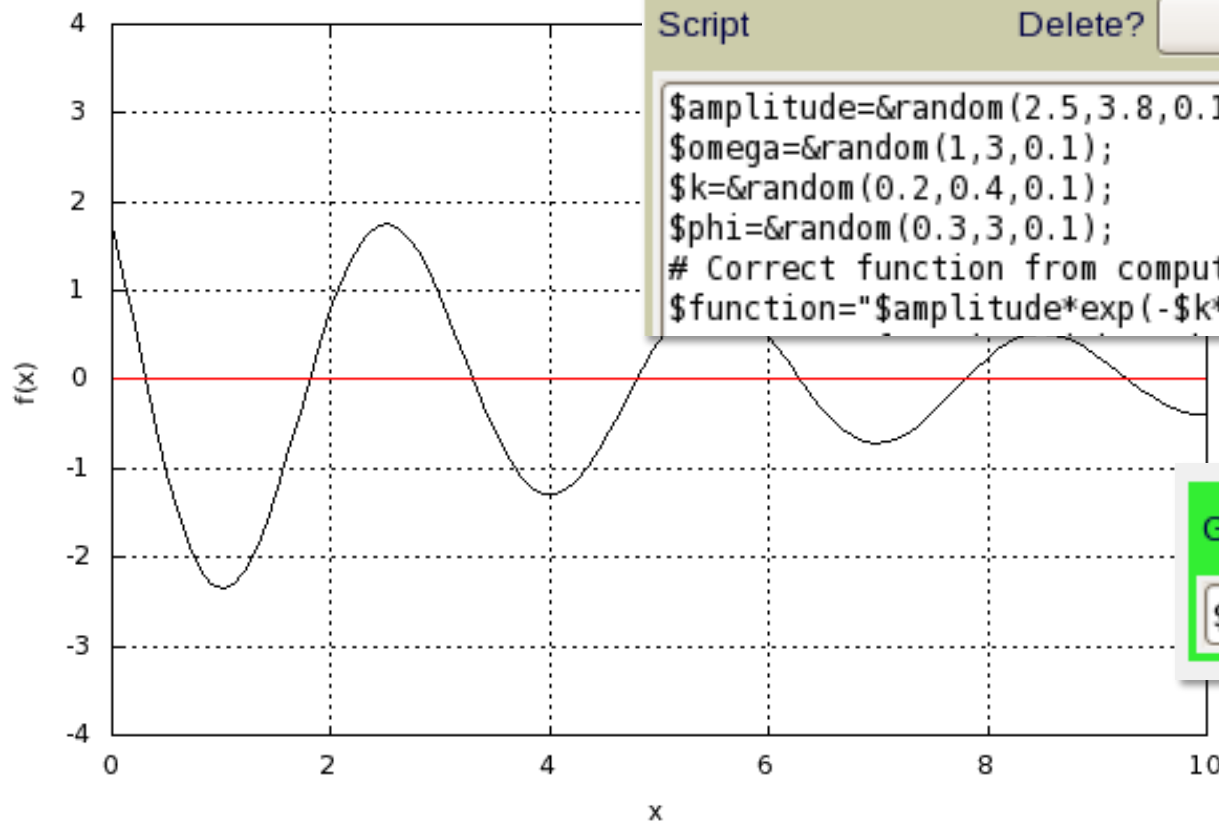
An object starts at the origin with a constant velocity of

$$\vec{v} = \begin{pmatrix} 4.4 \\ 2.5 \\ 7.2 \end{pmatrix} \begin{matrix} \text{m} \\ \text{s} \end{matrix}$$

Where is it 4 seconds later?

- Simplest input: numerical

Mathematics Input



Script

Delete?

```
$amplitude=&random(2.5,3.8,0.1);  
$omega=&random(1,3,0.1);  
$k=&random(0.2,0.4,0.1);  
$phi=&random(0.3,3,0.1);  
# Correct function from computer  
$function="$amplitude*exp(-$k*x)*sin($omega*x+$phi)";
```

Gnuplot compatible curve function

`$function`

Match the function indicated in black.

f(x)=



Response: Formula

Delete?

Insert:

Answer: `$function`


Sample Points: `x@0;1;2;3;4;5;6;7;8;9`

- Sampling – approximate function

Mathematics Input

Script Delete?

```
$k=&random(3,6,1);  
$formula="a*x^$k";  
$m=$k-1;  
$derivative="$k*a*x^$m";
```

What is the derivative of $a \cdot x^4$ with respect to x ? 

Tries 0

Answer for Part: 0

What is the derivative of $\langle \text{algebra} \rangle \$formula \langle / \text{algebra} \rangle$ with respect to x ?

[Check Spelling](#)

rt:

Response: Formula Delete? Insert:

Answer: Sample Points:

- Symbolically: exactly one exact answer (but equivalent forms)

Mathematical Input

- Checking properties
 - Using R:

Provide a list of 3 numbers (separated by commas) that has a mean value of 6.2.

Response: Math Delete?

String to display for answer: Algebra System:

Libraries:

Answer algorithm Delete?

```
x<-c (RESPONSE[1],RESPONSE[2],RESPONSE[3]);  
abs (mean (x) -LONCAPALIST[1])<0.001
```

Mathematical Input

- Checking properties
 - Using MAXIMA:

Give an example of a function

1. which is orthogonal to

$$-2 \cdot \cos(5 \cdot x) + 2 \cdot \sin(4 \cdot x)$$

with respect to the scalar product

$$\langle g | h \rangle = \frac{1}{\pi} \int_{-\pi}^{\pi} dx g(x) \cdot h(x)$$

2. whose norm is 1.

Submit Answer

Try

Answer algorithm

```
overlap:integrate((RESPONSE[1])*(LONCAPALIST[1]),x,-%pi,%pi)/%pi;  
norm:integrate((RESPONSE[1])*(RESPONSE[1]),x,-%pi,%pi)/%pi;  
is(overlap=0 and norm=1);
```

Mathematical Input

- Checking properties
 - Using Perl and MAXIMA:

Write 9/20 as an Egyptian Fraction

```
# Subroutine that checks if the provided term is indeed an Egyptian Fraction
sub analyze {
    my ($expression)=@_;
    $expression=~s/\s//gs;
    $expression=~s/\+?1\//\,/gs;
    if ($expression=~/^(\,[0-9]+)+$/ ) {
# Format is indeed 1/n+1/m+...
        $last=-1;
        foreach $number (sort { $a<=>$b } split(/\,/,$expression)) {
# Is a number used twice?
            if ($last==$number) { return(0,1); }
            $last=$number;
        }
        return(0,0);
    }
    return(1,0);
}
```

Answer algorithm

Delete?

```
# Analyze the format
($formaterror,$doubleerror)=&analyze($submission);
if ($formaterror || $doubleerror) { return 'WRONG_FORMAT'; }
# It is an Egyptian Fraction, is the value correct?
if (&cas('maxima',$submission.'-('$egyptian.')) eq '0') {
    return 'EXACT_ANS';
}
return 'INCORRECT';
```

Mathematical Input

The screenshot shows a web browser window with a math applet. On the left, a graph plots a function $f(x)$ on the y-axis (ranging from -4 to 4) against x on the x-axis (ranging from 0 to 4). The function is a smooth curve that starts at $(0, 2)$, reaches a peak of approximately 3.1 at $x \approx 0.8$, crosses the x-axis at $x \approx 1.5$, reaches a trough of approximately -1.9 at $x \approx 2.2$, crosses the x-axis again at $x \approx 3.2$, reaches a second peak of approximately 1.2 at $x \approx 3.8$, and ends at $(4, 0.8)$. A red horizontal line is drawn at $f(x) = 0$. The applet interface includes buttons for "New Randomization", "Change Random Seed To", "Edit", and "EditXML".

On the right, a Mozilla Firefox window displays the URL `https://s10.lite.msu.edu/adm/dragmath/applet/MaximaPopup.html`. The math editor toolbar includes symbols for $\frac{1}{x}$, \sqrt{x} , $(0)[]$, \sin , $\int \frac{1}{x}$, π , and $\frac{1}{x}$. Below the toolbar, the function $e^{-(0.3) \cdot x}$ is entered in the input field. A "Save & Close" button is visible at the bottom of the editor. The status bar at the bottom of the browser window reads "Applet DragMath started".

Match the function indicated in black.

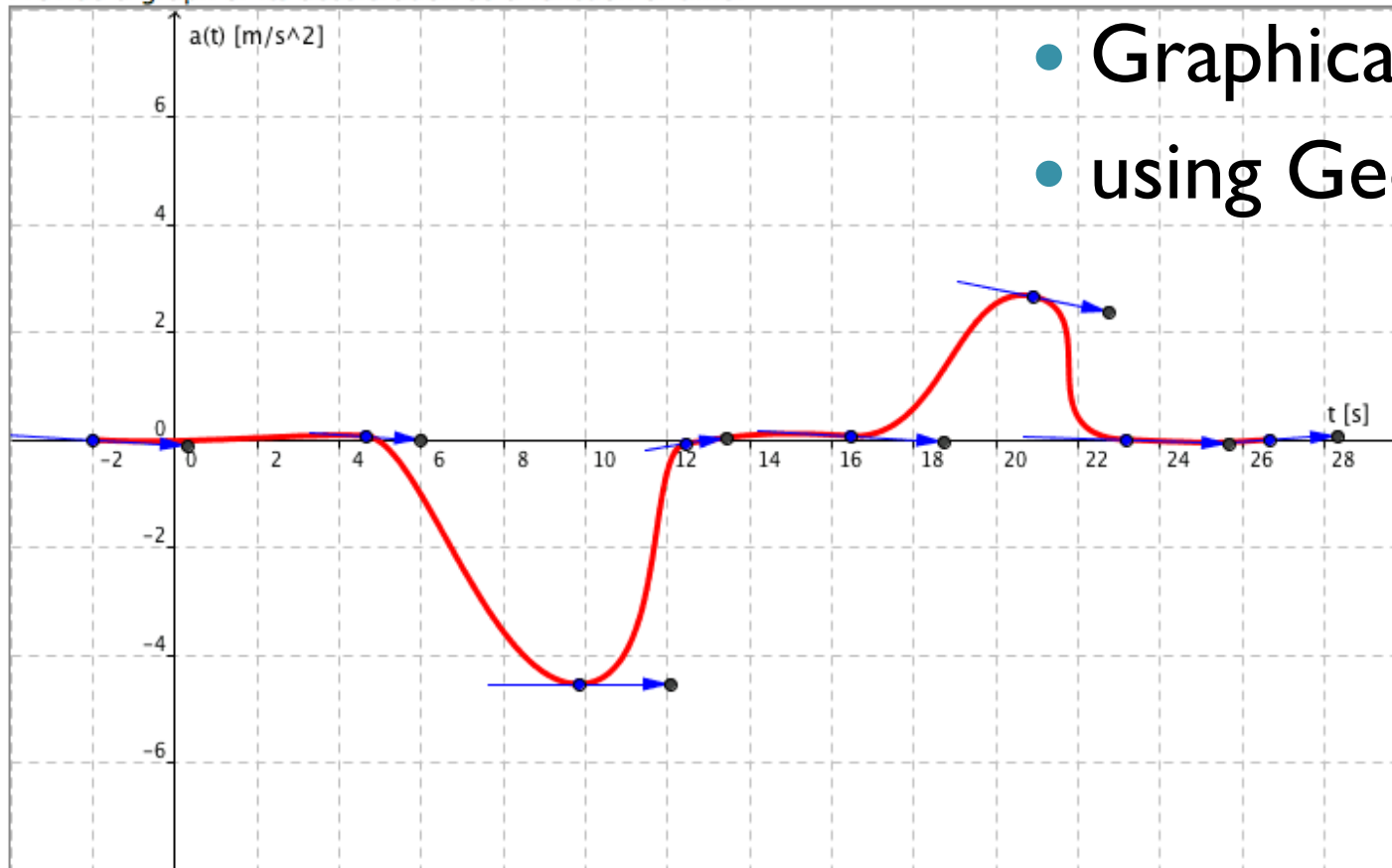
$f(x) =$

Tries 0/99

Math editor for students

Mathematical Input

At $t=0$ s, a car cruises at a constant positive velocity. Suddenly, a light switches to red. At $t=10$ s, the driver is maximum on the brake. The car then stops in front of the red light for over 2 seconds. Eventually, it drives off, and then again cruises at a constant velocity. The car cannot accelerate with more than 3 m/s^2 . Provide a graph of its acceleration as a function of time.



- Graphical input
- using Geogebra

You are correct. Computer's answer now shown above. [Previous Tries](#)

[Script Vars](#)
[Rules Log](#)

Mathematical Input

- Rulesets

Function
First Derivative
Second Derivative
Integral

Function Plot Evaluation Rule Delete? Evaluatio

Index/Name: Function:

Initial x-value: Initial x-value label:

Final x-value (optional): Final x-value label (optional):

Minimum length for range (optional): Maximum length for range (optional):

Relationship:

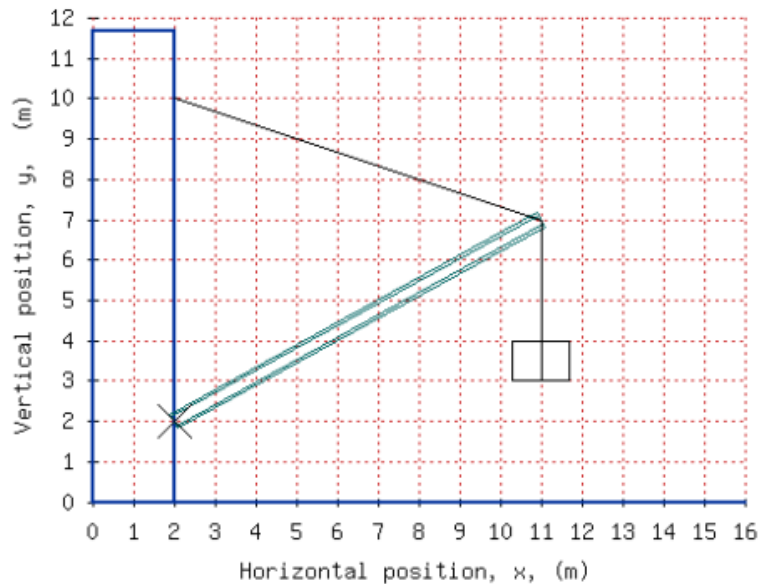
Percent error:

Symbolic, computed, or
hard-coded ranges

Mathematical Input

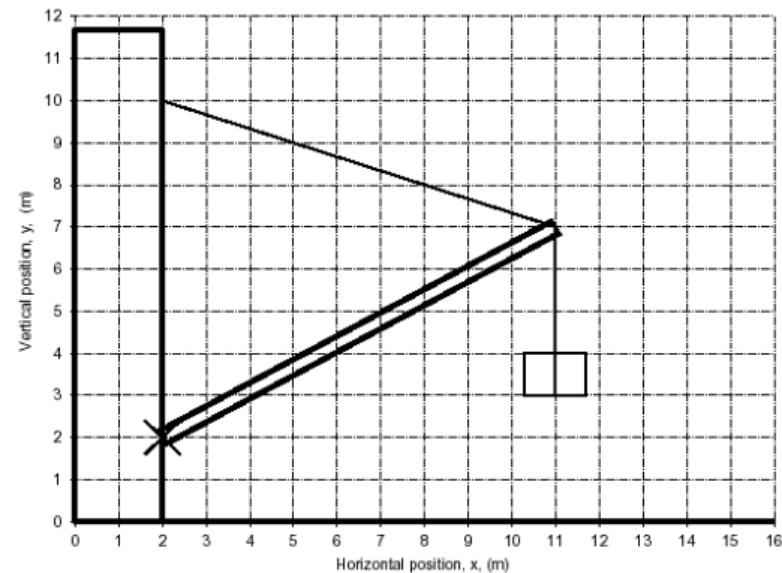
- Problems can also be rendered for bubble sheets
- Every student gets a different version

A crate with a mass of 177.5 kg is suspended from the end of a uniform boom with mass of 88.5 kg. The upper end of the boom is supported by a cable attached to the wall and the lower end by a pivot (marked X) on the same wall. Calculate the tension in the cable.



Submit Answer

1 pt A crate with a mass of 177.5 kg is suspended from the end of a uniform boom with mass of 88.5 kg. The upper end of the boom is supported by a cable attached to the wall and the lower end by a pivot (marked X) on the same wall. Calculate the tension in the cable.



(in N)

22. A 2.58×10^3 B 2.92×10^3 C 3.29×10^3
 D 3.72×10^3 E 4.21×10^3 F 4.75×10^3
 G 5.37×10^3 H 6.07×10^3

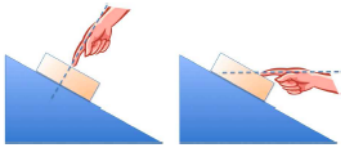
Mathematical Input

CODE - AACHDA
LB 271 - Introductory Physics Lecture
Version A

Name:

LB271 Fall 2009 Final Exam Version A

Gravitational Acceleration on Earth	$g = 9.81 \text{ m/s}^2$
Gravitational Constant	$G = 6.67 \cdot 10^{-11} \text{ m}^3/(\text{kg} \cdot \text{s}^2)$
Absolute Zero	-273.15°C
Gas Constant	$R = 8.31 \text{ J}/(\text{K} \cdot \text{mol})$
Boltzmann Constant	$k = 1.38 \cdot 10^{-23} \text{ J/K}$
Avogadro's number	$N_A = 6.02 \cdot 10^{23} \text{ particles/mol}$
Specific heat of water vapor	$c_{\text{vapor}} = 0.48 \text{ kcal}/(\text{kg} \cdot \text{K})$
Specific heat of liquid water	$c_{\text{water}} = 1 \text{ kcal}/(\text{kg} \cdot \text{K})$ $= 4186 \text{ J}/(\text{kg} \cdot \text{K})$
Specific heat of water ice	$c_{\text{ice}} = 0.5 \text{ kcal}/(\text{kg} \cdot \text{K})$
Latent heat of fusion for water	$L_f = 80 \text{ kcal/kg}$
Latent heat of vaporization for water	$L_v = 540 \text{ kcal/kg}$



A block is being held in place on an incline. The magnitude of the force applied by the hand on the block is the same in the left and the right scenarios.

1 pt In which scenario does the incline exert a lower normal force on the block?

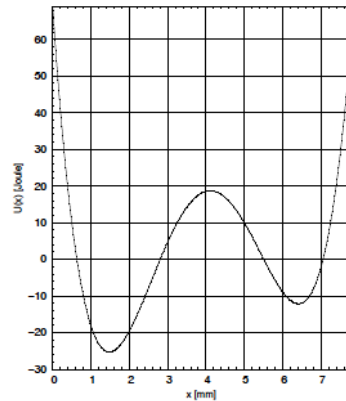
1. A The left scenario.
 B The right scenario.
 C Same in both scenarios.

1 pt In which scenario does the incline exert a lower frictional force on the block?

2. A The left scenario.
 B The right scenario.
 C Same in both scenarios.

1 pt By how many decibels does the sound intensity from a point source decrease if you increase the distance to it by a factor 6?

3. A 12.2 B 13.8 C 15.6 D 17.6
 E 19.9 F 22.5 G 25.4 H 28.7



1 pt

A particle is located at $x=2.0$ mm and has a kinetic energy of 29.5 Joule. What is the maximum x-coordinate the particle could reach? (in mm)

4. A 0.1 B 0.7 C 1.6 D 2.6
 E 3.2 F 4.7 G 5.3 H 7.6



Deep Space Nine sees Enterprise and a shuttle approach from exactly opposite directions with $0.8c$ and $0.5c$, respectively.

1 pt At what fraction of the speed of light (β) does Enterprise see the shuttle approach?

5. A 0.00 B 0.50 C 0.83 D 0.91
 E 0.93 F 1.00 G 1.25 H 1.30

1 pt The shuttle has a length of 9 meters when at rest. How long is it in the system of Deep Space 9? (in m)

6. A 1.8 B 2.6 C 3.7 D 5.4
 E 7.8 F 11.3 G 16.4 H 23.8

1 pt Captain Picard on the Enterprise takes a 49 minute tea break. How long is this break in the system of Deep Space 9? (in min)

7. A 27 B 33 C 42 D 52
 E 65 F 82 G 102 H 128

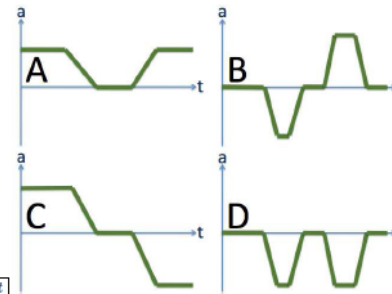
CODE - AACHDA
LB 271 - Introductory Physics Lecture
Version A

1 pt You have two organ pipes of the same length, one closed at both ends, one half open. Which one has a lower fundamental frequency?

8. A The closed pipe.
 B Same.
 C The half-open pipe.

1 pt In a very simple model of the lower atmosphere, air has a constant density of 1.26 kg/m^3 . How much would the air pressure change over a height difference of 130 m? (in Pa)

9. A 986 B 1110 C 1260 D 1420
 E 1610 F 1820 G 2050 H 2320



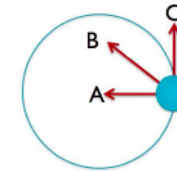
1 pt

A car drives in the forward (positive) direction. It first has a constant speed, then drives into a parking spot, waits for a few moments, and then drives out again backwards. Which one of the acceleration graphs could describe this scenario?

10. A Scenario A
 B Scenario B
 C Scenario C
 D Scenario D
 E None of the above.

1 pt A box is sliding uphill as shown. What is the direction of the frictional force on the box?

11. A Downhill.
 B Perpendicular to the surface.
 C Uphill.
 D None of the above.



An object is rotating on a circular trajectory as shown. The indicated direction A is toward the center of the trajectory, C is tangential to the trajectory. The object is **rotating clockwise and slowing down**.

1 pt What could be the direction of the (linear) acceleration?

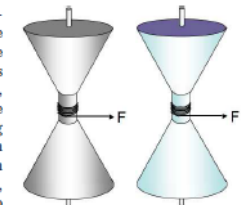
12. A Direction A.
 B Direction B.
 C Direction C.
 D Into the paper.
 E Out of the paper.

1 pt What could be the direction of the angular acceleration?

13. A Direction A.
 B Direction B.
 C Direction C.
 D Into the paper.
 E Out of the paper.

1 pt

You have two identical looking spools (same mass, same shape, same size). However, one is hollow, made from iron, the other is solid, made from aluminum. A string is wound around each spool. If you pull on both strings with equal forces, which spool is going to have the larger angular acceleration?



14. A Same
 B The solid spool
 C The hollow spool

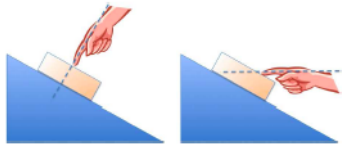
Mathematical Input

CODE - AAFIHH
LB 271 - Introductory Physics Lecture
Version A

Name:

LB271 Fall 2009 Final Exam Version A

Gravitational Acceleration on Earth	$g = 9.81 \text{ m/s}^2$
Gravitational Constant	$G = 6.67 \cdot 10^{-11} \text{ m}^3/(\text{kg} \cdot \text{s}^2)$
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A block is being held in place on an incline. The magnitude of the force applied by the hand on the block is the same in the left and the right scenarios.

1 pt In which scenario does the incline exert a higher frictional force on the block?

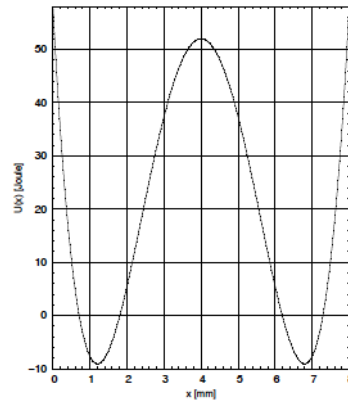
- A The left scenario.
- B The right scenario.
- C Same in both scenarios.

1 pt In which scenario does the incline exert a higher normal force on the block?

- A The left scenario.
- B The right scenario.
- C Same in both scenarios.

1 pt By how many decibels does the sound intensity from a point source decrease if you increase the distance to it by a factor 6?

- A 0.710
- B 0.831
- C 0.972
- D 11.4
- E 13.3
- F 15.6
- G 18.2
- H 21.3



1 pt

A particle is located at $x = 5.5 \text{ mm}$ and has a kinetic energy of 9.8 Joule. What is the minimum x-coordinate the particle could reach? (in mm)

- A 1.6
- B 2.6
- C 2.7
- D 2.9
- E 3.0
- F 3.8
- G 5.2
- H 6.9



Deep Space Nine sees Enterprise and a shuttle approach from exactly opposite directions with $0.8c$ and $0.4c$, respectively.

1 pt At what fraction of the speed of light (β) does Enterprise see the shuttle approach?

- A 0.00
- B 0.47
- C 0.50
- D 0.59
- E 0.78
- F 0.91
- G 1.00
- H 1.20

1 pt The shuttle has a length of 12 meters when at rest. How long is it in the system of Deep Space 9? (in m)

- A 3.6
- B 4.5
- C 5.6
- D 7.0
- E 8.8
- F 11.0
- G 13.7
- H 17.2

1 pt Captain Picard on the Enterprise takes a 35 minute tea break. How long is this break in the system of Deep Space 9? (in min)

- A 19
- B 28
- C 40
- D 58
- E 85
- F 123
- G 178
- H 258

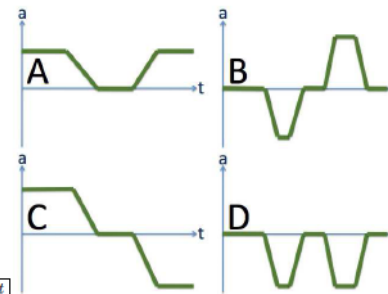
CODE - AAFIHH
LB 271 - Introductory Physics Lecture
Version A

1 pt You have two organ pipes of the same length, one closed at both ends, one half open. Which one has a lower fundamental frequency?

- A Same.
- B The closed pipe.
- C The half-open pipe.

1 pt In a very simple model of the lower atmosphere, air has a constant density of 1.22 kg/m^3 . How much would the air pressure change over a height difference of 110 m? (in Pa)

- A 1320
- B 1490
- C 1680
- D 1900
- E 2150
- F 2430
- G 2740
- H 3100



1 pt

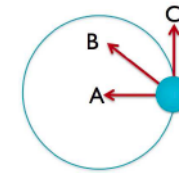
A car drives in the forward (positive) direction. It first has a constant speed, then drives into a parking spot, waits for a few moments, and then drives out again backwards. Which one of the acceleration graphs could describe this scenario?

- A Scenario A
- B Scenario B
- C Scenario C
- D Scenario D
- E None of the above.

1 pt

A box is sliding uphill as shown. What is the direction of the frictional force on the box?

- A Perpendicular to the surface.
- B Downhill.
- C Uphill.
- D None of the above.



An object is rotating on a circular trajectory as shown. The indicated direction A is toward the center of the trajectory, C is tangential to the trajectory. The object is **rotating clockwise and slowing down**.

1 pt What could be the direction of the (linear) acceleration?

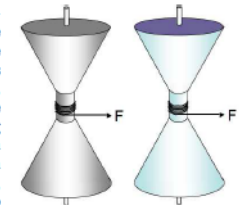
- A Direction A.
- B Direction B.
- C Direction C.
- D Into the paper.
- E Out of the paper.

1 pt What could be the direction of the angular acceleration?

- A Direction A.
- B Direction B.
- C Direction C.
- D Into the paper.
- E Out of the paper.

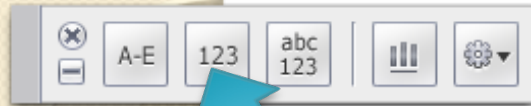
1 pt

You have two identical looking spools (same mass, same shape, same size). However, one is hollow, made from iron, the other is solid, made from aluminum. A string is wound around each spool. If you pull on both strings with equal forces, which spool is going to have the larger angular acceleration?



- A The solid spool
- B The hollow spool
- C Same

Mathematical Input



Numerical Clicker
in Lecture

Resistance

Current through a resistor



What is the current in milliamperes?

Mathematical Input

LON-CAPA can evaluate clicker data after lecture

LON-CAPA Change Preferences

http://phy1.lbs.msu.edu/adm/p

Getting Started Latest Headlines

LON-CAPA Course Statistics an... LON-CAPA Change Preferences

Main Menu Launch Remote Control Roles Help Exit

Change Preferences

Gerd The Kortemeyer
No Role, Cumulative Privileges

Menu->Set User Preferences->Register Clicker

Enter response device ("clicker") numbers

005BC59E

Register

Mathematical Input


[Main Menu](#)[Return to Last Location](#)[Navigate Contents](#)

Grading (msu_8p96131ebae7b47b8msul1 ss08lbs272)

Current Resource: Mon, Mar 10th

Part: 0 score **Type: numerical**

Specify a file containing the clicker information for this resource.

 MonMar10thA.csv

Type:

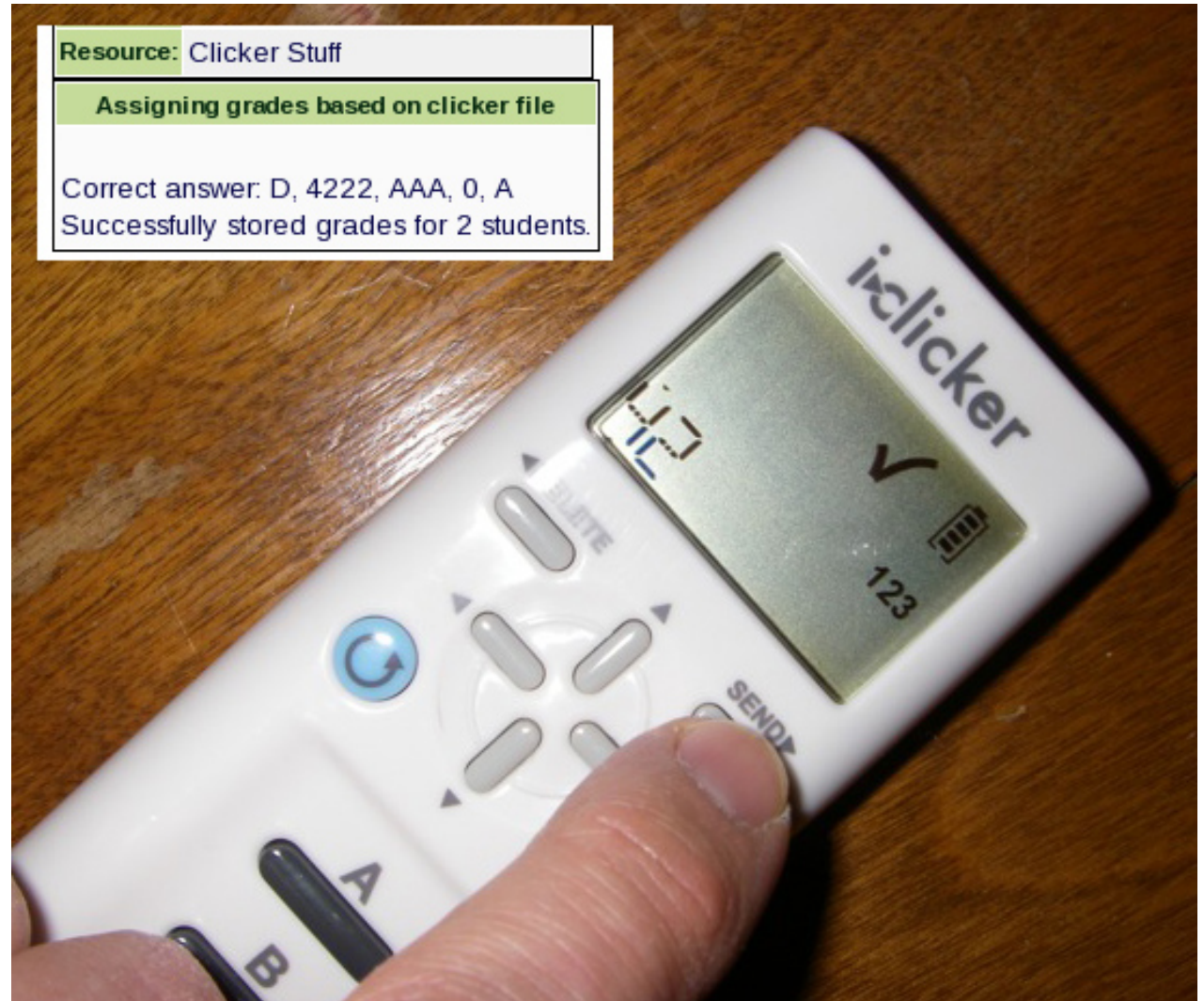
- Award points just for participation
- Correctness determined from response by course personnel
- Correctness determined from response with clicker ID(s)

Percentage points for correct solution:

Percentage points for incorrect solution:

Mathematical Input

- i>clicker2 integrated in LON-CAPA





Thank You

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and

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