

**Info...**

- A **Quiz** is due tonight.
- A new **EMCFs** and **Homework** are posted.


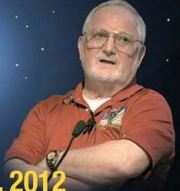
**Sy Liebergot, Former NASA Flight Controller**

“Apollo13: The Longest Hour”

**Tuesday, November 13  
7 – 8 pm in SEC 100**

## “Apollo 13: The Longest Hour”

Sy Liebergot, Former NASA Flight Controller





**Tuesday, November 13, 2012  
7 – 8 p.m.**

**Science and Engineering Classroom Building (SEC), Room 100  
(Building 529 on the UH Campus Map)  
University of Houston**

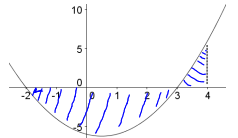
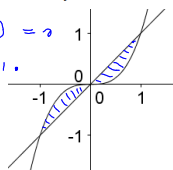
Hear what it was like to be a front-line Flight Controller in NASA's Mission Control when a monster failure occurred during the Apollo 13 mission to the moon. Sy Liebergot will share his reactions, NASA footage, and details of the explosion and the heroic efforts to bring the crew back safely to Earth. He'll also discuss the Apollo 13 movie's accuracy and how he met Tom Hanks and Ron Howard.

\* Sponsored by the Houston-Louis Stokes Alliance for Minority Participation and the College of Natural Sciences and Mathematics



**UNIVERSITY of HOUSTON**  
COLLEGE of NATURAL SCIENCES & MATHEMATICS

**Popper P27**

- $\int_{-2}^4 (x^2 - x - 6) dx =$  
- Find the area bounded between the x-axis and the graph of  $y = x^2 - x - 6$  on the interval  $[-2, 4]$ .  $-\int_{-2}^3 (x^2 - x - 6) dx + \int_3^4 (x^2 - x - 6) dx$
- Find the area bounded between the curves  $y = x$  and  $y = x^3$ .  
 $x^3 = x \implies x^3 - x = 0 \implies x(x^2 - 1) = 0 \implies x = -1, 0, 1$   
  
Note: The Area btwn  $x$  and  $x^3$  on  $[-1, 0]$  is the same as the area btwn  $x$  and  $x^3$  on  $[0, 1]$ .  
 So, Area =  $2 \int_0^1 (\text{Top} - \text{Bottom}) dx = 2 \int_0^1 (x - x^3) dx$   
 $= 2 \left( \frac{1}{2} x^2 - \frac{1}{4} x^4 \right) \Big|_0^1 = 2 \left[ \left( \frac{1}{2} - \frac{1}{4} \right) - (0) \right] = \frac{1}{2}$

$\int f(x) dx = F(x) + C$  An anti-deriv. + Constant  
 = The general anti-derivative of  $f$ .

No limits of integration  $\rightarrow$  "The indefinite integral of  $f$ ."

"The integral of  $f$ ." } Any 2 anti-deriv. differ by a constant.

Note: Since  $f(x)$  is continuous, opse  $F(x)$  and  $G(x)$  are anti-derivatives of  $f(x)$ .

Define  $H(x) = F(x) - G(x)$ .

Pick an interval  $[a, b]$  where this is defined. MVT  $\Rightarrow$  there is a value  $c$  btwn  $a$  and  $b$  so that  $H'(c) = \frac{H(b) - H(a)}{b - a}$ .

$\downarrow$   
 $F'(c) - G'(c)$   
 $\downarrow$   
 $f(c) - f(c)$   
 $\downarrow$   
 $0$

$\therefore H(b) = H(a)$   
 i.e. since  $a$  and  $b$  are arbitrary  $H(x) \equiv \text{constant}$ .

**Examples:**  $\int x^2 dx = \frac{1}{3} x^3 + C$  *arbitrary constant*

$\int \cos(x) dx = \sin(x) + C$

$\frac{d}{dx}(-\cos(2x)) = \sin(2x) \cdot 2$

$\int \sin(2x) dx = -\frac{1}{2} \cos(2x) + C$

$\int \left(-x^2 + \sqrt{x} - \frac{3}{x^2}\right) dx = \int \left(-x^2 + x^{1/2} - 3x^{-2}\right) dx$

$\int x^n dx = \frac{1}{n+1} x^{n+1} + C$   
 $n \neq -1$

$= -\frac{1}{3} x^3 + \frac{2}{3} x^{3/2} + 3x^{-1} + C$

**Note:** Most differentiation involves the chain rule, so we should expect that most antidifferentiation will involve

**undoing the chain rule.**

(u-substitution)

**Undoing the chain rule...**

$F'(x)$	$F(x)$
$2 \cos(2x)$	$\sin(2x) + C$
$2x \cos(x^2)$	$\sin(x^2) + C$
$\cos(u) \frac{du}{dx}$	$\sin(u) + C$
$8x(x^2+1)^3$	$(x^2+1)^4 + C$
$(n+1) u^n \frac{du}{dx}$	$u^{n+1} + C$ ( $n \neq -1$ )
$u^n \frac{du}{dx}$	$\frac{1}{n+1} u^{n+1} + C$
$\sin(u) \frac{du}{dx}$	$-\cos(u) + C$

**Undoing the chain rule...**

$\int u^n du = \frac{1}{n+1} u^{n+1} + C$ ,  $n \neq -1$

$\int \cos(u) du = \sin(u) + C$

$\int \sin(u) du = -\cos(u) + C$

$\int \sec^2(u) du = \tan(u) + C$   
others?

$\int \csc^2(u) du = -\cot(u) + C$

**Examples:**  $\int \cos(2x) dx = \sin(2x) + C$

$u = x^2$   
 $du = 2x dx$   
 $\int x \sin(x^2) dx = \frac{1}{2} \int \sin(\underline{x^2}) \underline{2x dx} = \frac{1}{2} \int \sin(u) du$   
 $= -\frac{1}{2} \cos(u) + C = -\frac{1}{2} \cos(x^2) + C$

$u = x^2 + 1$   
 $du = 2x dx$   
 $\int x(x^2 + 1)^4 dx = \frac{1}{2} \int (x^2 + 1)^4 \underline{2x dx} = \frac{1}{2} \int u^4 du$   
 $= \frac{1}{10} u^5 + C = \frac{1}{10} (x^2 + 1)^5 + C$

$u = 2 + \sin(x)$   
 $du = \cos(x) dx$   
 $\int \frac{\cos(x)}{\sqrt{2 + \sin(x)}} dx = \int (2 + \sin(x))^{\frac{1}{2}} \underline{\cos(x) dx}$   
 $= \int u^{-\frac{1}{2}} du = 2 u^{\frac{1}{2}} + C$   
 $= 2 \sqrt{2 + \sin(x)} + C$

**Question:** How do we handle  $u$ -substitution with a definite integral?

**Answer:** We change the limits of integration to reflect the substitution.

**Example:**  $\int_0^1 3x^2 \sin(2x^3 - 1) dx =$

$u = 2x^3 - 1$   
 $du = 6x^2 dx$   
 $x=1 \Rightarrow u=1$   
 $x=0 \Rightarrow u=-1$

$$= \frac{1}{2} \int_{-1}^1 \sin(u) du$$

$$= \frac{1}{2} \int_{-1}^1 \sin(u) du$$

$$= -\frac{1}{2} \cos(u) \Big|_{-1}^1$$

Note:

$\cos(1) = \cos(-1)$

b/c

cosine is even.

$= -\frac{1}{2} (\cos(1) - \cos(-1))$

$= 0$

**Example:**  $\int_{-2}^1 x(x^2 + 1)^4 dx =$

See the video!!