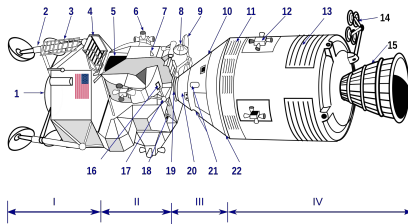


Welcome to
ASEN 3502
Computational Methods

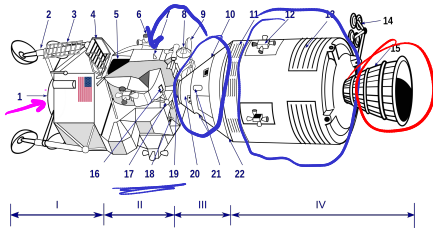
Apollo 13



I-II: lunar module (descent, ascent stages); III: command module; IV: service module.

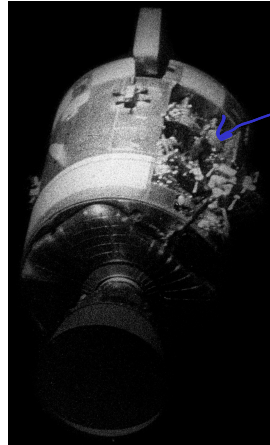
Popadius, Wikimedia Commons, CC0.

Apollo 13



I-II: lunar module (descent, ascent stages); III: command module; IV: service module.

Popadius, Wikimedia Commons, CC0.



The service module after separation, with one panel blown off. NASA (scan by Kipp Teague), public domain.

Direct return

NASA-S-66-4979 MAY 25

DIRECT RETURN MODE FOR TL COAST

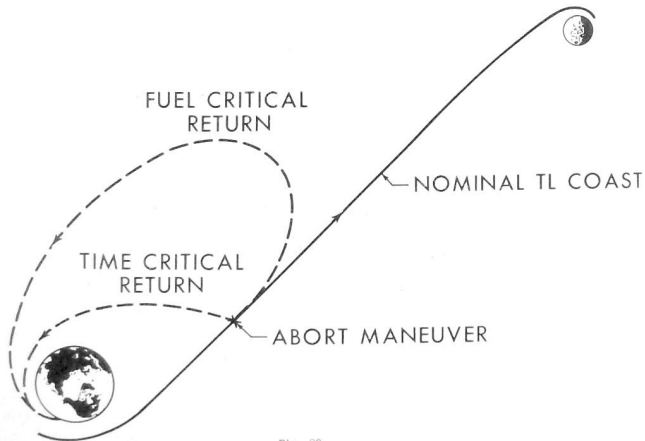
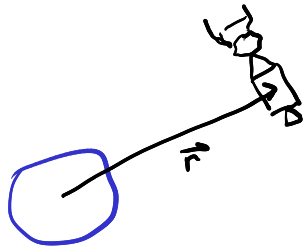


Fig. 20

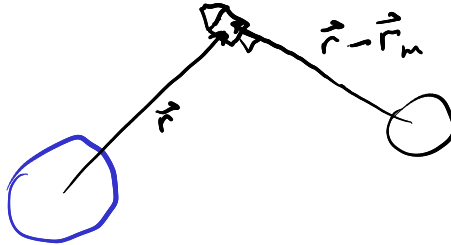
R. L. Berry, *Apollo Lunar Landing Mission Symposium*, NASA MSC, June 1966. Public domain, via Wikimedia

Commons.



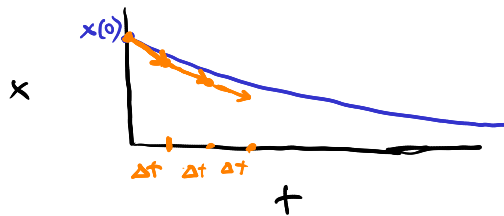
$$\ddot{\vec{r}} = -\frac{\mu_e}{r^2} \frac{\vec{r}}{r} \rightarrow \text{elliptical hyperbolic}$$

$$\mu_e = G m_e$$



$$\ddot{\vec{r}} = -\frac{\mu_e}{r^2} \frac{\vec{r}}{r} - \frac{\mu_m}{\|\vec{r} - \vec{r}_m\|^2} \frac{\vec{r} - \vec{r}_m}{\|\vec{r} - \vec{r}_m\|}$$

no easy analytical solution



$$\dot{x} = -ax$$

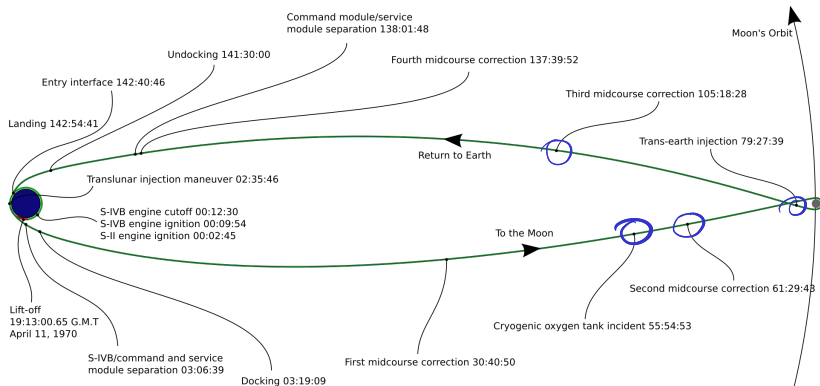
Euler's Method

$$\text{Error} = O(\Delta t)$$

Runge-Kutta

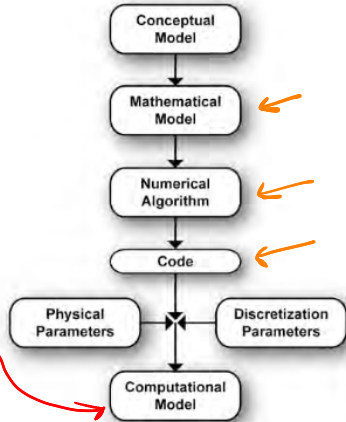
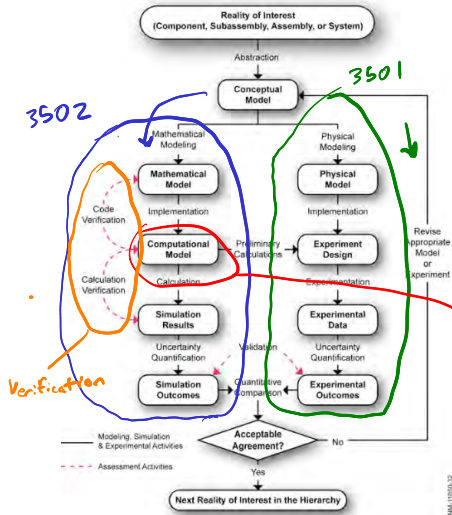
$$\text{Error} = O(\Delta t^4)$$

What Apollo 13 actually flew



AndrewBuck, Wikimedia Commons, CC BY-SA 4.0. Source for figures: Apollo 13 Mission Report, p. 3-2.

ASME V&V 10

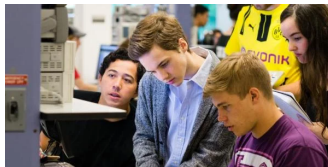


Your code is not done until you verify it with tests

asen3502.com

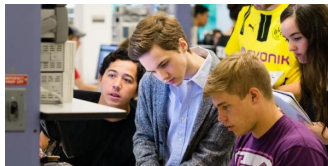
Our Assumptions

- The material is challenging, and can take multiple engagements to understand fully



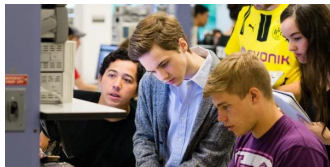
Our Assumptions

- ▶ The material is challenging, and can take multiple engagements to understand fully
- ▶ A student who comes to my office or asks a question wants to learn



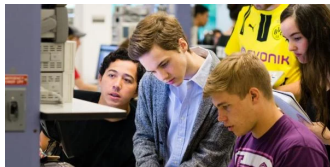
Our Assumptions

- ▶ The material is challenging, and can take multiple engagements to understand fully
- ▶ A student who comes to my office or asks a question wants to learn
- ▶ It may take multiple ways of explaining a concept before a student understands



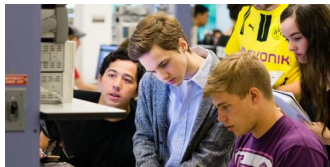
Our Assumptions

- ▶ The material is challenging, and can take multiple engagements to understand fully
- ▶ A student who comes to my office or asks a question wants to learn
- ▶ It may take multiple ways of explaining a concept before a student understands
- ▶ We must work together to help you find the way to understand



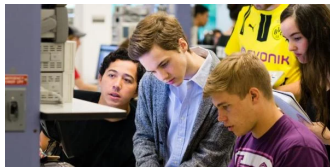
Our Assumptions

- ▶ The material is challenging, and can take multiple engagements to understand fully
- ▶ A student who comes to my office or asks a question wants to learn
- ▶ It may take multiple ways of explaining a concept before a student understands
- ▶ We must work together to help you find the way to understand
- ▶ Taking notes in class and doing the homework yourselves are critical steps to understanding



Our Assumptions

- ▶ The material is challenging, and can take multiple engagements to understand fully
- ▶ A student who comes to my office or asks a question wants to learn
- ▶ It may take multiple ways of explaining a concept before a student understands
- ▶ We must work together to help you find the way to understand
- ▶ Taking notes in class and doing the homework yourselves are critical steps to understanding
- ▶ I am trying to bring you to the point of understanding, not just give you the answer



Our Assumptions

- ▶ The material is challenging, and can take multiple engagements to understand fully
- ▶ A student who comes to my office or asks a question wants to learn
- ▶ It may take multiple ways of explaining a concept before a student understands
- ▶ We must work together to help you find the way to understand
- ▶ Taking notes in class and doing the homework yourselves are critical steps to understanding
- ▶ I am trying to bring you to the point of understanding, not just give you the answer
- ▶ We will have fun this semester

