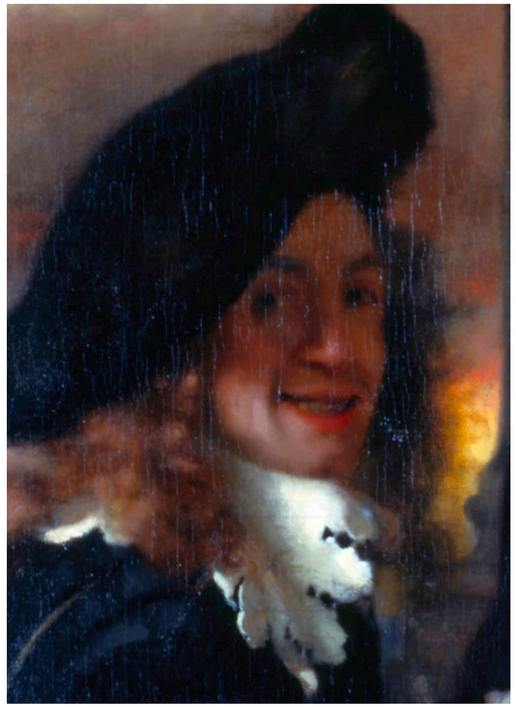
Van Meegeren art forgeries

From M. Braun, “Differential Equations and their applications”, 4th ed., Springer

Disciples at Emmaus,
by Johannes Vermeer (1632-1675)

- "**the** masterpiece of Johannes Vermeer of Delft!", according to Abraham Bredius
- sold to the Rembrandt society for 170,000$ (about $4M today) in 1937

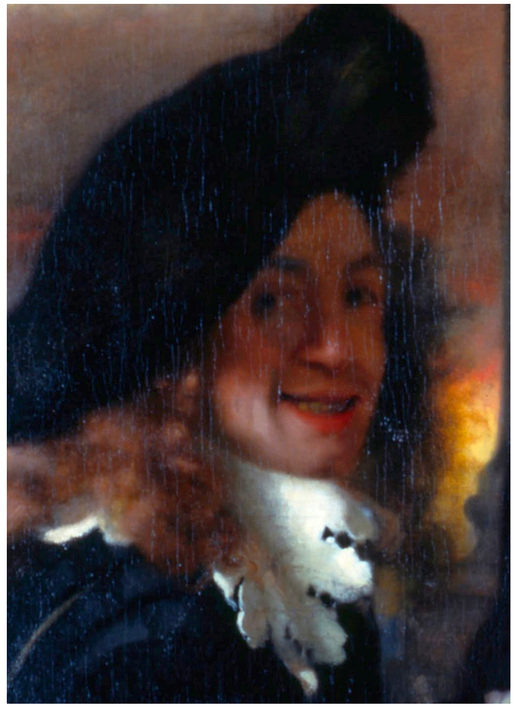
detail of the painting *The Procuress*,
believed to be a self portrait by Vermeer



Disciples at Emmaus,
by Johannes Vermeer (1632-1675)

- "**the** masterpiece of Johannes Vermeer of Delft!", according to Abraham Bredius
- sold to the Rembrandt society for 170,000$ (about $4M today) in 1937

detail of the painting *The Procuress*,
believed to be a self portrait by Vermeer



Girl with a pearl earring

Han van Meegeren (1889-1947)

Dutch painter
Got arrested at the end of World War II for collaboration with the Nazis

To defend himself, he claimed to have fooled the Germans by selling them lots of fake paintings of famous Dutch painters:

in particular, *Woman taken in adultery* and *Disciples of Emmaus*

Han van Meegeren (1889-1947)

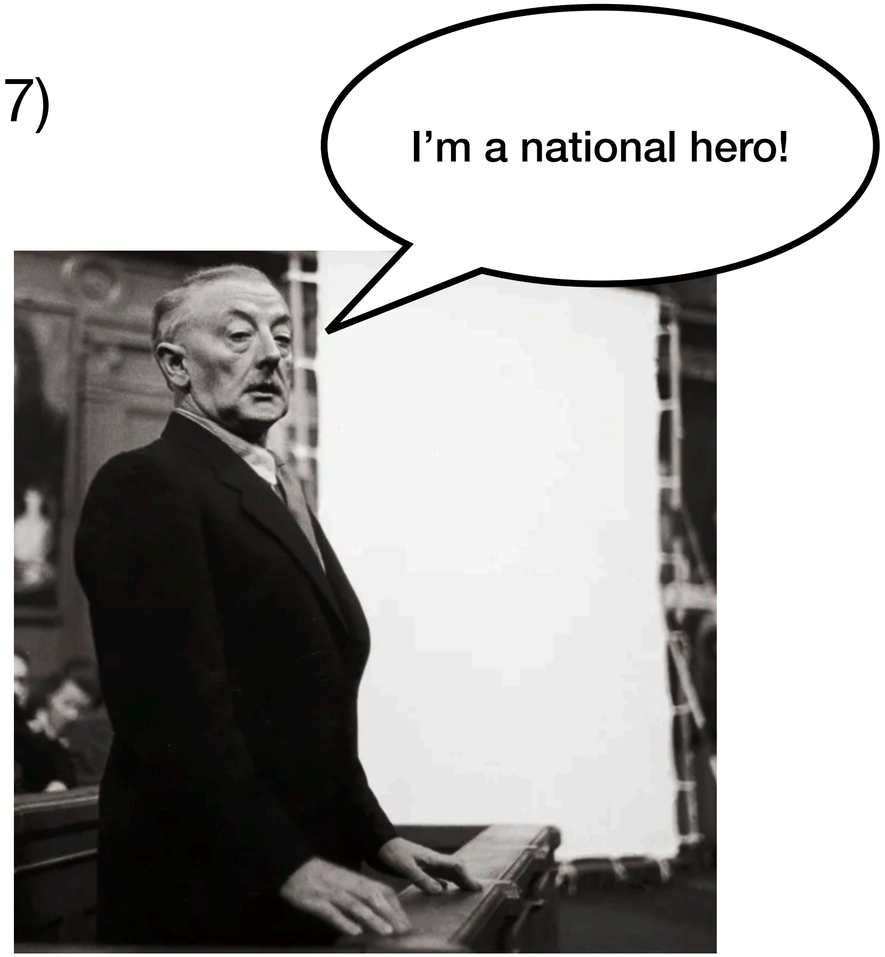
Dutch painter
Got arrested at the end of World War II for collaboration with the Nazis

To defend himself, he claimed to have fooled the Germans by selling them lots of fake paintings of famous Dutch painters:

in particular, *Woman taken in adultery* and *Disciples of Emmaus*

Han van Meegeren (1889-1947)

Dutch painter
Got arrested at the end of World War II for collaboration with the Nazis



To defend himself, he claimed to have fooled the Germans by selling them lots of fake paintings of famous Dutch painters:

in particular, *Woman taken in adultery* and *Disciples of Emmaus*

Woman taken in adultery and other less famous paintings were easily recognized as a fake.

Van Meegeren was convicted to one year of prison of forgery and died shortly after.

However, the question about authenticity on *Disciples of Emmaus* remained…

?

Woman taken in adultery and other less famous paintings were easily recognized as a fake.

Van Meegeren was convicted to one year of prison of forgery and died shortly after.

However, the question about authenticity on *Disciples of Emmaus* remained…

?

The answer was found by scientists at Carnegie Mellon University in 1967

Radioactive decay:

Atoms of certain "radioactive" elements are unstable and within a given time period
a proportion of the atoms spontaneously disintegrates to form atoms of a new element.

Radioactivity of a substance is directly proportional to the number of atoms of the substance present.

$$\frac{dy}{dt} = -\lambda y$$

$$y(t_0) = y_0$$

Radioactive decay:

Atoms of certain "radioactive" elements are unstable and within a given time period
a proportion of the atoms spontaneously disintegrates to form atoms of a new element.

Radioactivity of a substance is directly proportional to the number of atoms of the substance present.

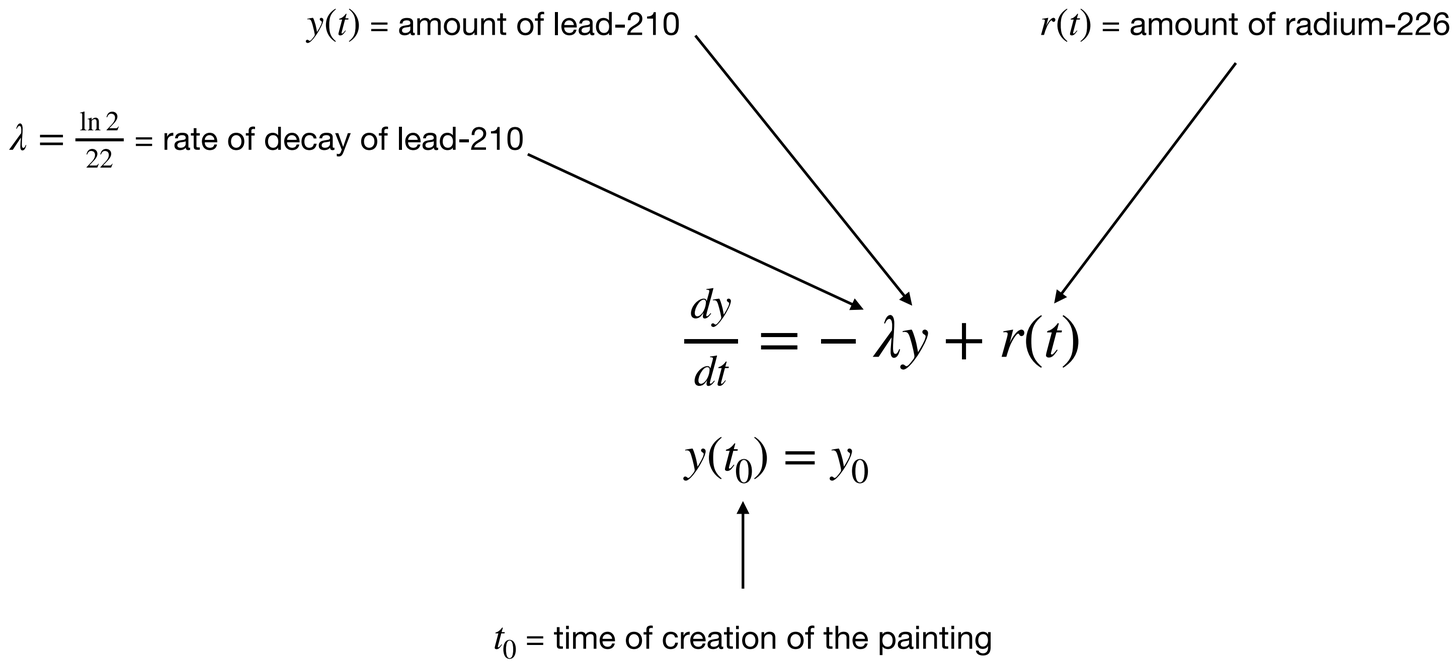
$$\frac{dy}{dt} = -\lambda y$$
$$y(t_0) = y_0$$

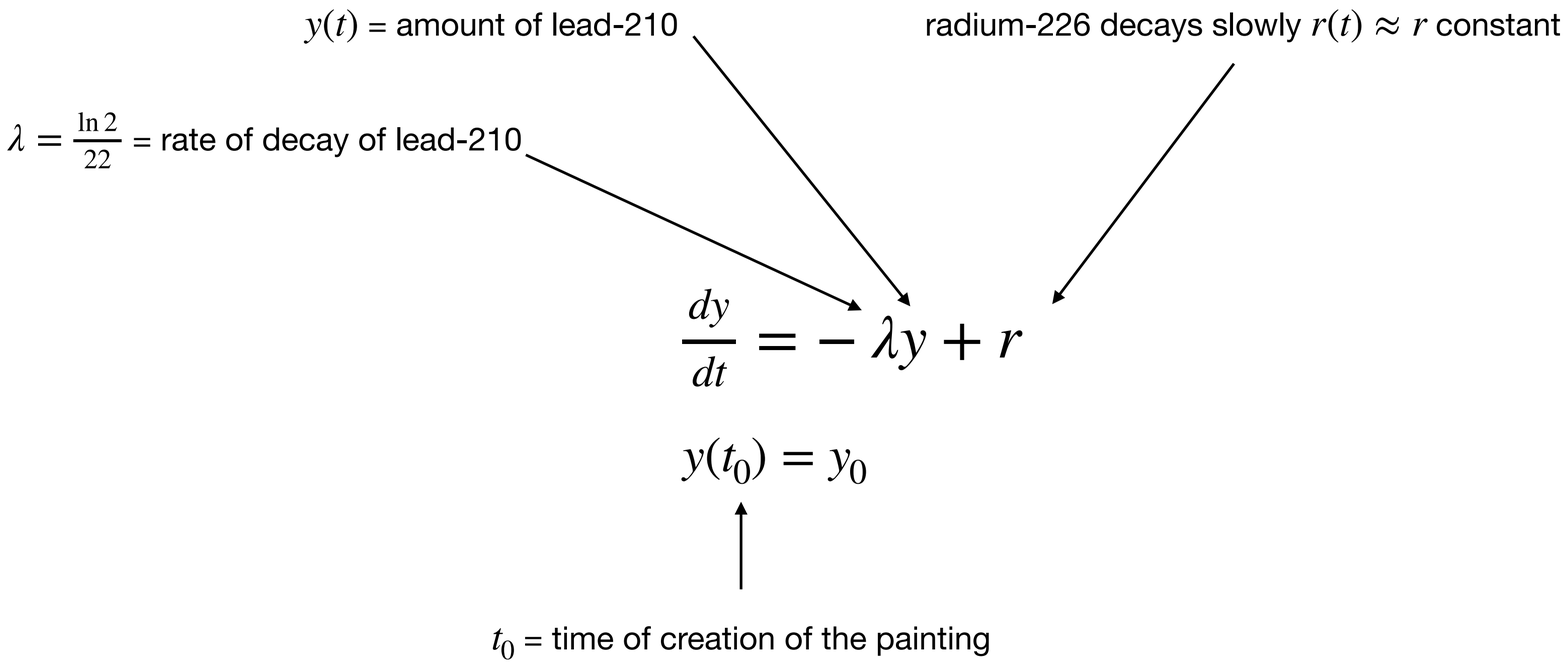
Separable equation: solution is

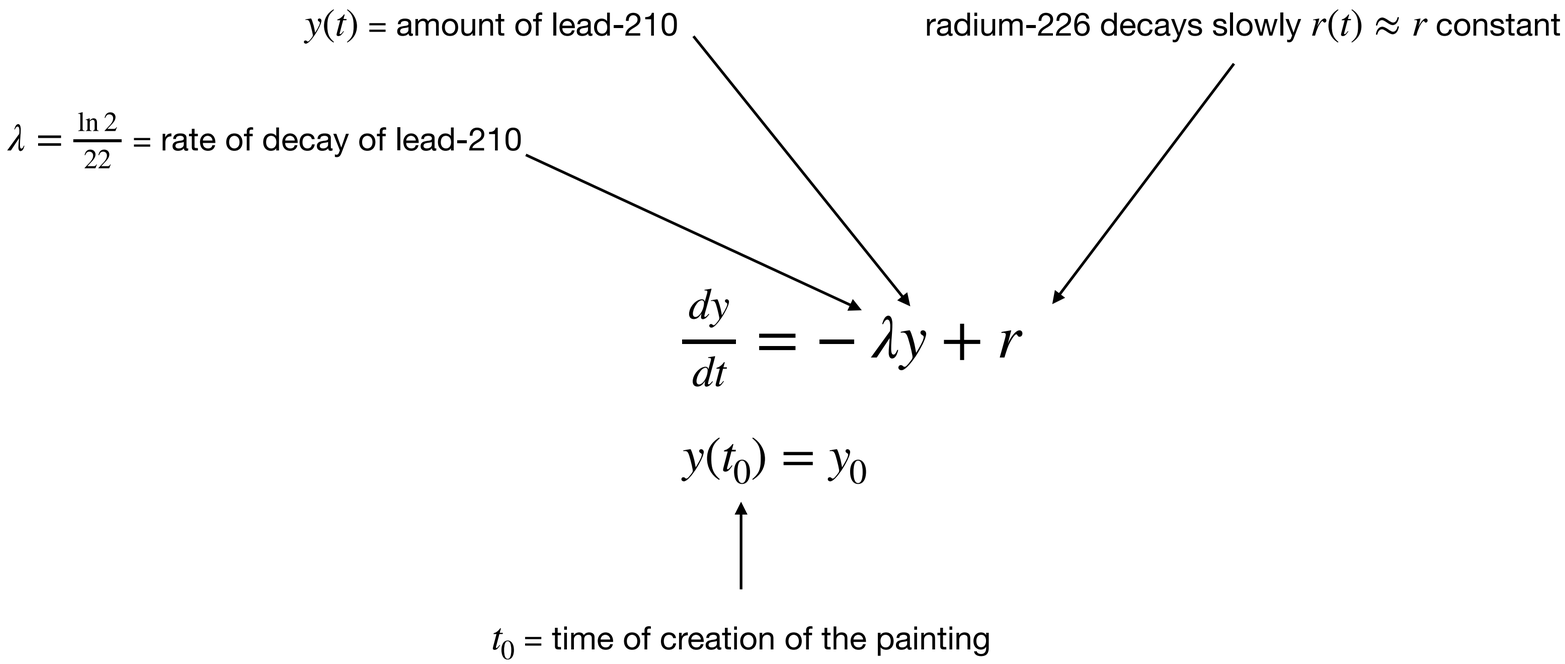
$$y(t) = y_0 e^{-\lambda(t-t_0)}$$

all paintings contain a pigment (white lead) that has a small amount of lead-210 and of radium-226 (two radioactive elements)

disintegration of the lead-210 is exactly balanced by the disintegration of the radium




$y(t)$ = amount of lead-210
radium-226 decays slowly $r(t) \approx r$ constant
$\lambda = \frac{\ln 2}{22}$ = rate of decay of lead-210
$\frac{dy}{dt} = -\lambda y + r$
$y(t_0) = y_0$
t_0 = time of creation of the painting



Linear equation: solution is

$$y(t) = \frac{r}{\lambda}(1 - e^{-\lambda(t-t_0)}) + y_0 e^{-\lambda(t-t_0)}$$

$$y(t) = \frac{r}{\lambda}(1 - e^{-\lambda(t-t_0)}) + y_0 e^{-\lambda(t-t_0)}$$

$$y(t) = \frac{r}{\lambda}(1 - e^{-\lambda(t-t_0)}) + y_0 e^{-\lambda(t-t_0)}$$

What we know:

- λ = rate of decay of lead-210
- r = amount of radium-266
- $y(t)$ = amount of lead-210 in the present day

$$y(t) = \frac{r}{\lambda}(1 - e^{-\lambda(t-t_0)}) + y_0 e^{-\lambda(t-t_0)}$$

What we know:

- λ = rate of decay of lead-210
- r = amount of radium-266
- $y(t)$ = amount of lead-210 in the present day

What we want to know:

- t_0 = when the pigment (painting) was made

$$y(t) = \frac{r}{\lambda}(1 - e^{-\lambda(t-t_0)}) + y_0 e^{-\lambda(t-t_0)}$$

What we know:

- λ = rate of decay of lead-210
- r = amount of radium-266
- $y(t)$ = amount of lead-210 in the present day

What we want to know:

- t_0 = when the pigment (painting) was made

What we're missing:

- y_0 = amount of lead-210 at the time of making
  (but we can estimate that!)

Assume the painting is indeed old: $t - t_0 \approx 300$ years

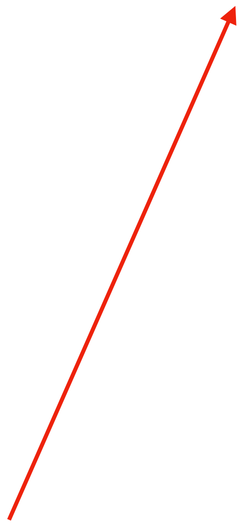
Rewrite the solution as

$$\begin{aligned}
\lambda y_0 &= \lambda y(t) e^{\lambda(t-t_0)} - r(e^{\lambda(t-t_0)} - 1) \\
&= \lambda y(t) e^{300\lambda} - r(e^{300\lambda} - 1) \\
&= 8.5 e^{300\frac{\ln 2}{22}} - 0.8(e^{300\frac{\ln 2}{2}} - 1) \\
&= 98{,}050
\end{aligned}$$

Assume the painting is indeed old: $t - t_0 \approx 300$ years

Rewrite the solution as

$$\begin{aligned}\lambda y_0 &= \lambda y(t) e^{\lambda(t-t_0)} - r(e^{\lambda(t-t_0)} - 1) \\ &= \lambda y(t) e^{300\lambda} - r(e^{300\lambda} - 1) \\ &= 8.5 e^{300\frac{\ln 2}{22}} - 0.8(e^{300\frac{\ln 2}{2}} - 1) \\ &= 98{,}050\end{aligned}$$



This quantity shouldn't be bigger than 30,000 (by comparing with old rocks)

Assume the painting is indeed old: $t - t_0 \approx 300$ years

Rewrite the solution as

$$\begin{aligned}\lambda y_0 &= \lambda y(t) e^{\lambda(t-t_0)} - r(e^{\lambda(t-t_0)} - 1) \\ &= \lambda y(t) e^{300\lambda} - r(e^{300\lambda} - 1) \\ &= 8.5 e^{300\frac{\ln 2}{22}} - 0.8(e^{300\frac{\ln 2}{2}} - 1) \\ &= 98{,}050\end{aligned}$$

This quantity shouldn't be bigger than 30,000 (by comparing with old rocks)

This painting is fake!!!