GRAVITY MEASURING DEVICES

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1.Introduction

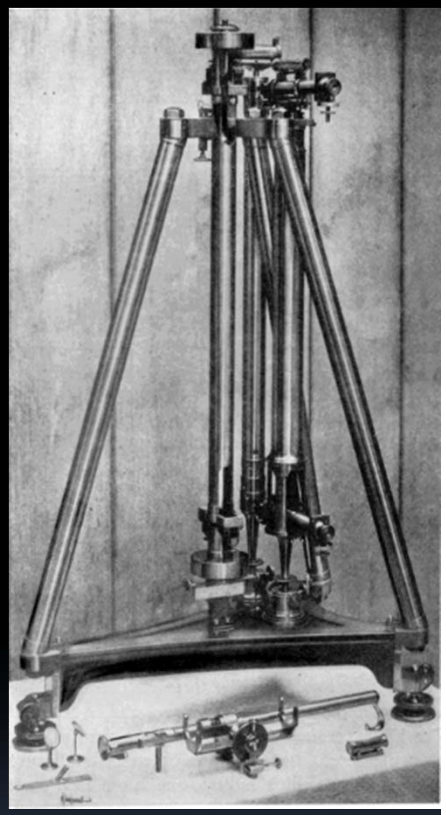
- Gravity is the combination of earth attraction force
- Gravity sensors fall into one of two categories

  - An absolute gravity instrument measures the local value of gravity each time it makes a measurement.
  - A relative gravity instrument measures the difference in gravity between measurements.

The absolute gravity hut at Dumont d'Urville, Antarctica

2.Advancements

- The historical advancement of gravity instrumentation has driven
  - Increased precision
  - Reduction in measurement time
  - Increased portability
  - Automation and ease of use
- About 40 different commercial gravity sensors and gravity gradiometers are available.
- Only six general types of gravity and gravity gradiometry sensors have been widely used



PENDULUM apparatus as made in 1875, and used in the gravity work of the U.S. Coast and Geodetic Survey

3. Instruments (Past to Present)

3.1 Pendulums

- Aristotle (384–322 BC):

  Velocity of a freely falling body is proportional to its weight

- Galileo Galilei (1604) :

  Free fall is a constant acceleration independent of mass

- Christian Huygens (1656):

  Developed the first pendulum clock and showed that a simple pendulum can be used to measure absolute gravity, *g*.

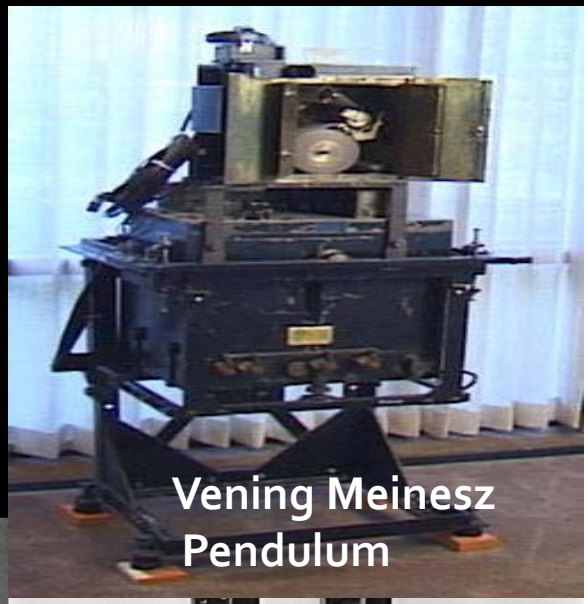
- Henry Kater (1817) :

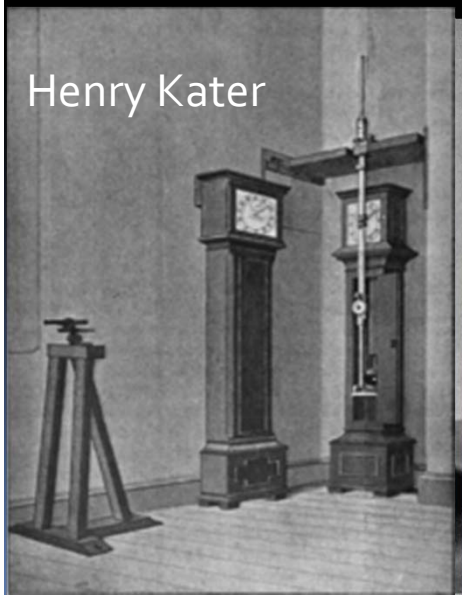
  Invented the reversible pendulum

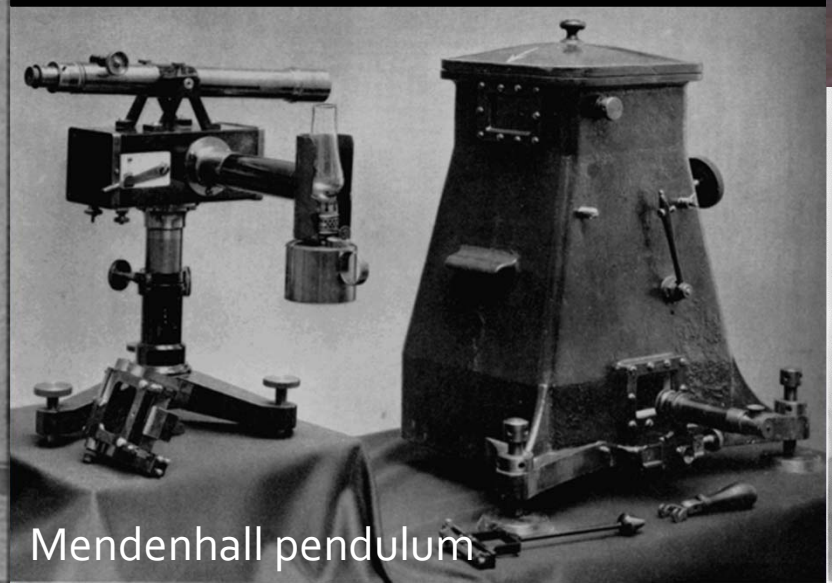
- Reversible pendulums were a substantial improvement in absolute gravity measurement.

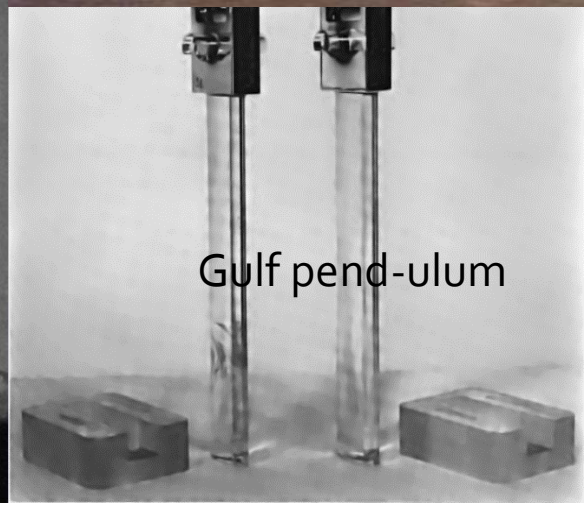
- Initial precision of about 10 mGal was reduced to 1mGals over hundred years.
- In the first half of the 1900's pendulums in use

  - Sterneck's pendulum (1887)
  - Mendenhall pendulum (1890)
  - Vening Meinesz pendulum (submarine 1929)
  - Gulf pendulum (1932)
  - Holweck-Lejay pendulum (1930-33)









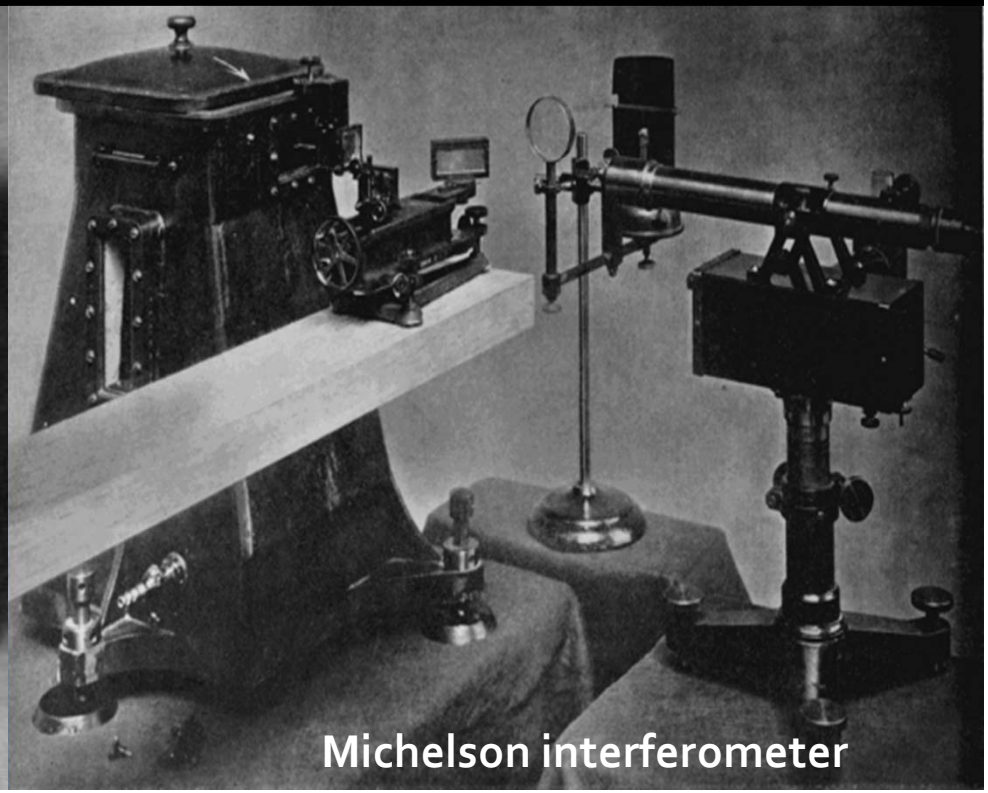
3.2 Free-fall gravimeter

- Free-fall gravimeters were first developed in 1952.
- The method involves measuring the time of flight of a falling body over a measured distance.
- Precise measurement of a short time period, became possible with the introduction of the quartz clock in the 1950's.

quartz clock in the 1950

- The first free-fall instruments used a white-light Michelson interferometer.
- Early 1970s, range of measurements 0.01 to 0.05 mGal,
- 1980, free-fall gravimeters replaced pendulums for absolute gravity measurements.

FG5 absolute gravimeter.


Michelson interferometer

3.3 Torsion-balance gravity gradiometer

- Developed by Baron Roland von Eotvos in 1896.
- Extensively used from 1918 to 1940
- Accuracies of a few Eotvos units (IE = 10–9 S–2 mGal/km)
- About three to six hours to obtain a gravity station
- Four to eight stations per day
- Could only be used in relatively flat areas.

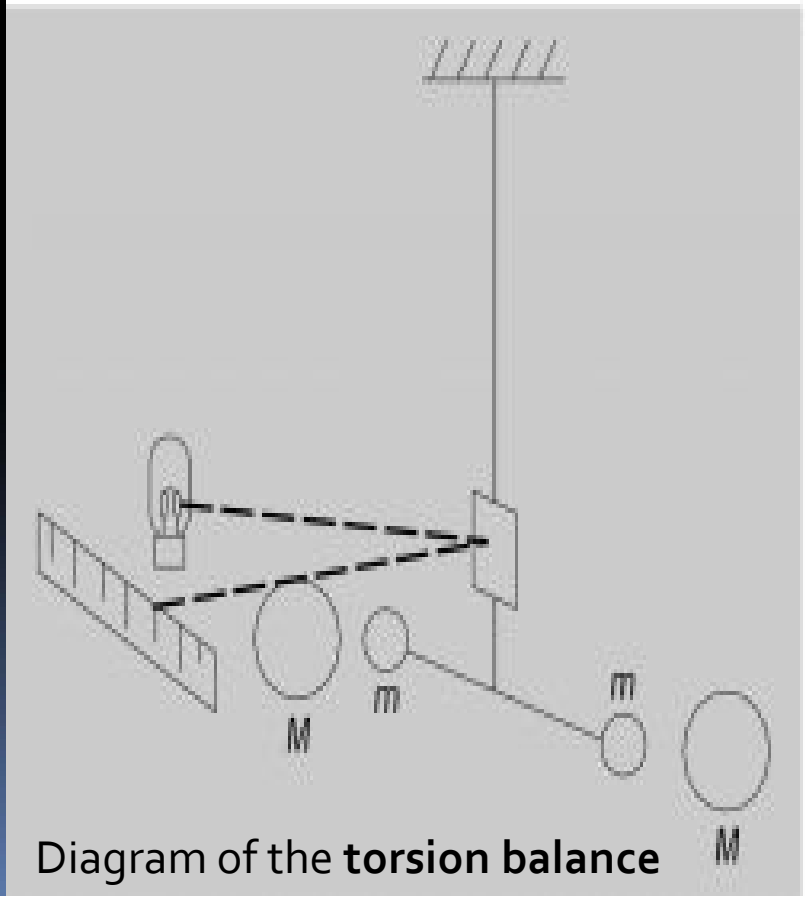
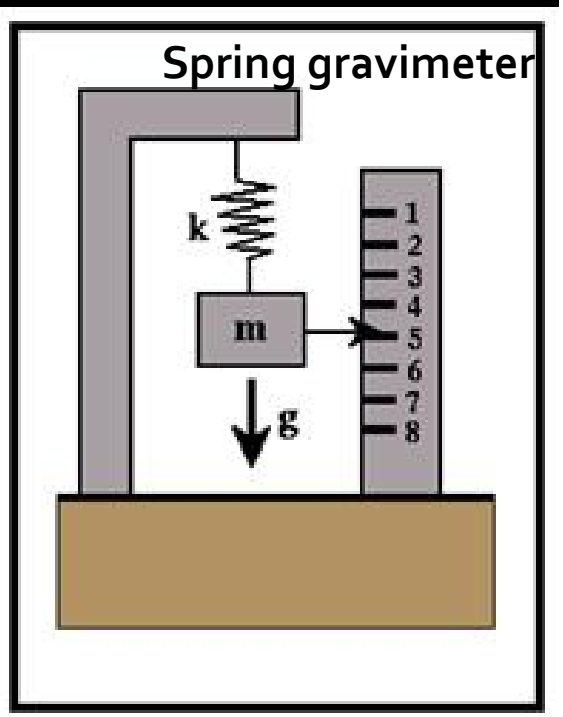


Diagram of the **torsion balance**

3.4 Spring gravimeters

- Spring gravimeters measure the change in the equilibrium position of a proof mass.
- Measurements were taken on the basis of one of these
  - The deflection of the equilibrium position
  - Measuring the magnitude of a restoring force
  - Measuring the change in a force
- Spring gravimeters classes :

  Stable or Unstable.
- Spring gravimeters uses an elastic spring for the restoring force, but a torsion wire may also be used.



- The simplest design is the straight-line gravimeter, which consists of a proof mass hung on the end of a vertical spring.
- During 1930 to 1950 the most successful was developed in 1939 by Lucien LaCoste and was zero-length spring gravity meter.
- In 1948, Sam Worden of Worden Gravity Meter Company introduced an inclined zero-length spring gravimeter that uses a spring made of fused quartz and sensitivity about 0.01 mGal.

3.5 Vibrating-string gravimeter

- The first vibrating-string gravimeters were developed by Gilbert (1949) for use on submarines and were later adapted for use in marine, land, and borehole applications.
- Physically smaller than spring gravimeters
- Since 1967, this system has been used for marine gravity surveys and are still in use in Russia and China

4.Borehole gravity instruments

- Borehole gravity meters (BHGMs) were first developed in the late 1950s in response to the petroleum industry's need.
- It used a vibrating-filament sensor, where the frequency of vibration was related to the tension on the filament, and the frequency changed as gravity varied.
- Thermostatically controlled to operate at temperatures up to 125°C

BHGM gravity sensor

5.Underwater gravity instruments

- Commonly land gravity meter with water proof shell and electronic system to operate remotely.
- In the 1940s, extensive seafloor gravity measurements were made for oil exploration in the Gulf of Mexico.

Underwater Gravimeter

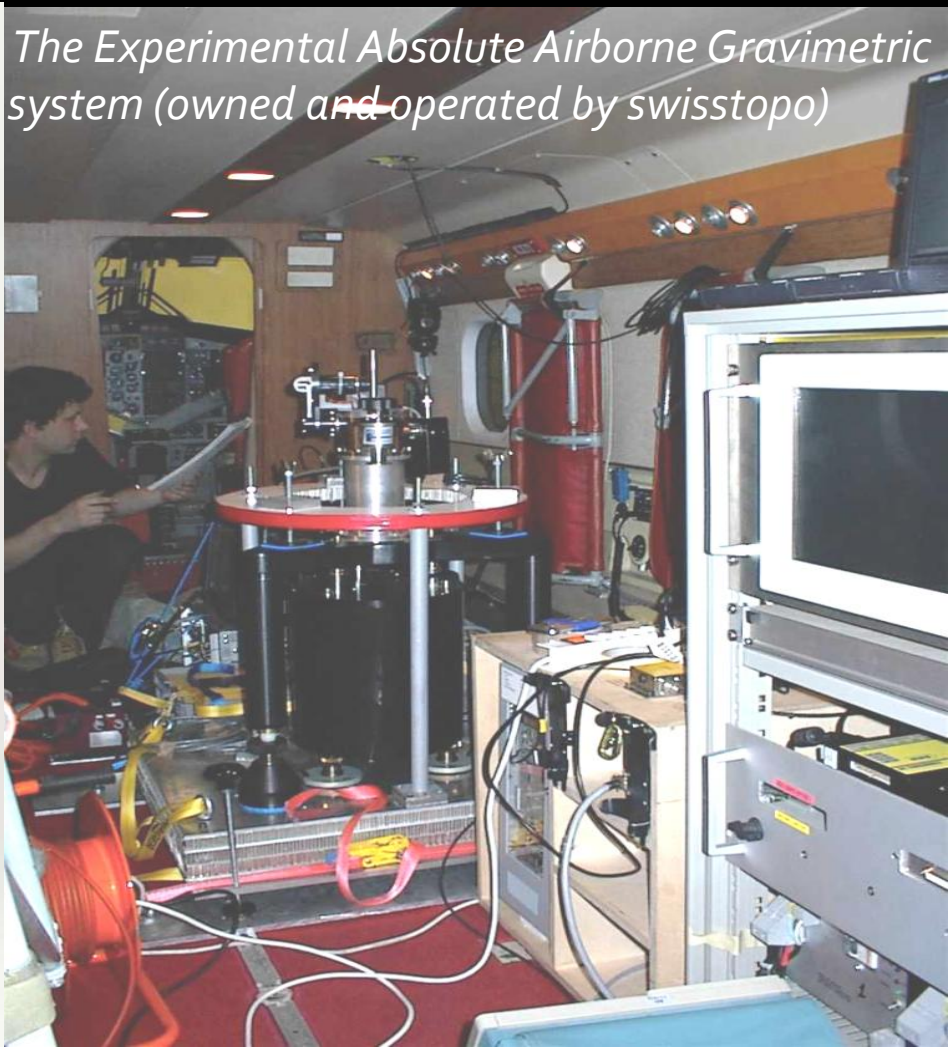
6.Moving-platform gravity instruments

- Large areas can be covered quickly using gravity sensors attached to moving platforms such as trucks, trains, airplanes, helicopters, marine vessels, or submarines.
- Gravity measurements are made primarily with spring gravimeters; vibrating-string

- Low-pass filtering is typically applied to minimize the effect of high-frequency accelerations of the platform.

Air-Sea Gravity System II

Micro-g LaCoste.



The Experimental Absolute Airborne Gravimetric system (owned and operated by swisstopo)