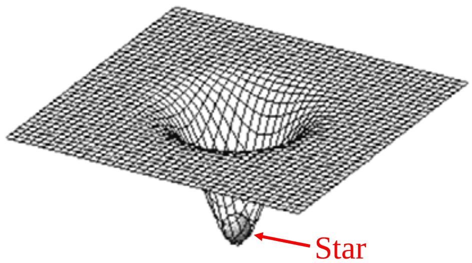
Newton

Gravity = a "force" between objects with mass

$$F_{gravity} = \frac{Gm_1m_2}{r^2}$$

General Relativity

- Worked out in 1907 - 1915
- Consistent with (incorporates) special relativity
- Describes motions of objects in presence of gravity
- Gravity **=** curvature of space-time.



[see Fig 13.12]

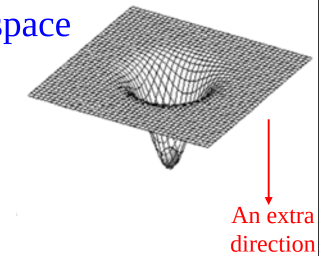
Announcements:
- Today's slides are on the web.
- Midterm 3 study guide now on web.
- Hwk 6 due on Monday evening.
- Midterm 3 on Wednesday.

Spacetime

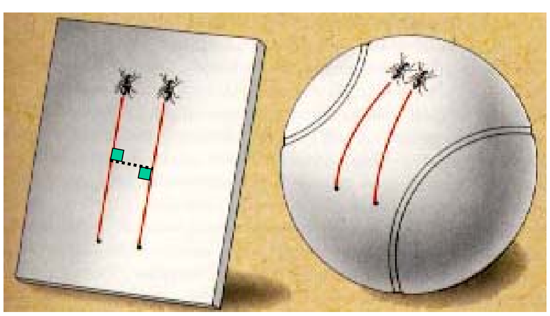
- Cross-talk between space & time
  ➔ think of time as 4^{th} dimension.
- But time is still different from space.
- Special Relativity:
  - 1 time-like, 3 space-like dimensions.

How many space-like dimensions do we live in?

- General Relativity
  - Space-time
  - But 3D space = “surface” in a 4D space
- Use easily visualized analogy
  - 2D surface in a 3D space
- Imagine a bug constrained to that 2D surface
  - Doesn’t know 3rd dimension exists.



Euclid & Friend go exploring

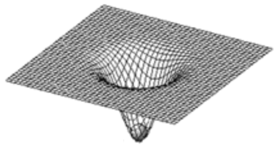


Parallel lines…

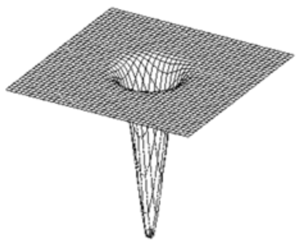
do funny things in curved geometries.

Gravity = distortion into extra space-like "dimensions".

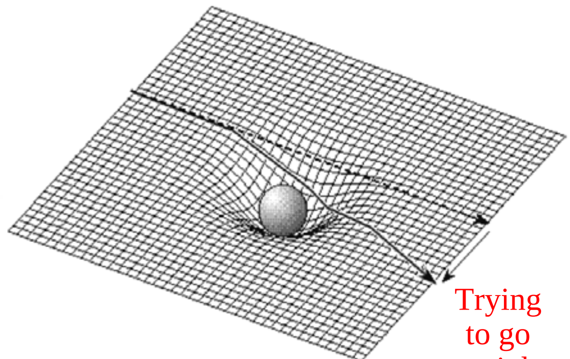
+ time distortions



Low mass star



High mass neutron star



See [Fig. 13.12]

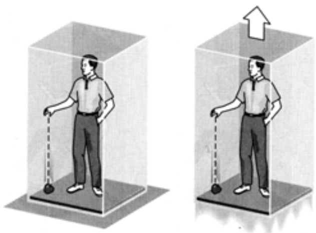
Einstein, on "the happiest thought of my life"…

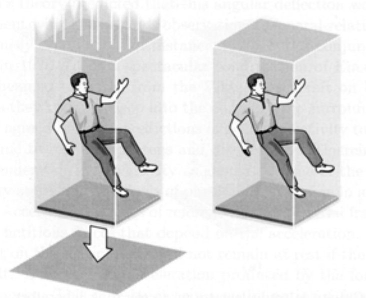
I was sitting in the patent office at Bern when all of a sudden a thought occurred to me:
"If a person falls freely he will not feel his own weight." *

*Or something like that in German.

The Principle of Equivalence

- A thought experiment: falling elevators.





Gravity

Upwards acceleration, no gravity.

Falling due to gravity

No gravity

- Can't tell difference between gravity & acceleration
- …or between freefall & no gravity.
- So *any* experiment should give same answer in either case.

The Equivalence Principle at Work