Newtonian Physics in Science Fiction Movies and TV : the Good, the Bad, and the Ugly

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Newton's First Law – Inertia

- An object at rest stays at rest (in the absence of external forces)
- An object in motion remains in motion with the same velocity (in the absence of external forces)
- All “inertial frames” are equivalent… in other words, the two previous statements are the *same thing.*

Aristotelean Physics – closer to our intuition

- The laws of the heavens and Earth are different
- The “natural” state of any object on Earth is at rest.

All stop.

Relative to what sir? As you know, the *Enterprise* is already at rest with respect to herself, and...

Data, just stop the bloody starship.

Newton's Second Law – The Force Law

$$F = m\,a$$

The harder you push on something the greater the rate at which it *accelerates* – that is, the greater the *rate of change* of speed.

Warp drive clearly doesn't obey Newtonian Physics (!!), but what about impulse drive? "Quarter impulse," "half impulse," etc., are always used as if they were speeds, not accelerations.

This makes sense for seacraft, where you have to deal with the drag of water resistance, but not for spacecraft!

Newton's Third Law – Action/Reaction

"Every action has an equal and opposite reaction"

(Huh?)

The floor is *pushing up* on your feet with a force equal to your weight.

When you jump, you push the Earth away from you, and the Earth pushes you away from it.

The tractor beam that pulls the Botany Bay towards the Enterprise also pulls the Enterprise towards the Botany Bay (although only a little bit).

1968: the dawn of the modern era of sci-fi movies:

2001: A Space Odyssey

Newtonian Physics is *rock solid* in this movie

1977: the dawn of the modern era of sci-fi movies

Star Wars

Newtonian Physics is *brutally murdered* in this movie– and it sets the standard!

Newton's 2nd law : Force is proportional to *acceleration*

We're goin' in full throttle; that ought to keep those fighters off our back!

Luke, at that speed will you be able to pull out in time?

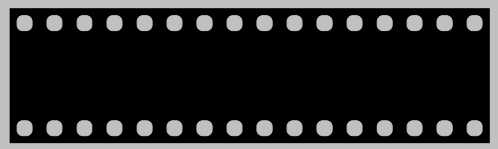
Doesn't survive the battle

("Speed?" What is this, an airplane?)

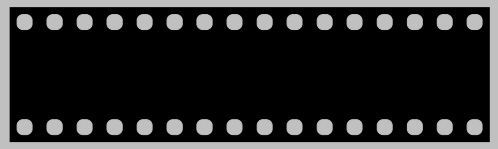
- Airplanes bank when they turn; they are pushing off of the air in the atmosphere.

- Fighters in space *would not* have to do this! (If they did, then people would be able to hear you scream in space.)

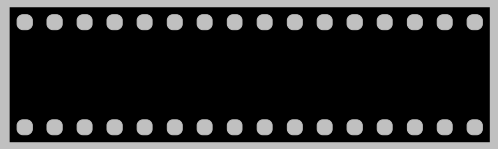
- Explosions billow because of expanding gasses pushing into the ambient air... of which there is not a lot in space.



- And what about that unhealthy obsession with firing the way you're moving, and with having things on your tail?



- One more example of “air” in space...



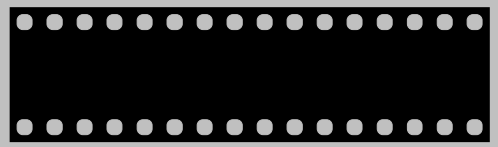
Is it possible to make fast-paced space battles while at least giving a *nod* to Sir Isaac??

...welcome to a nerd's paradise...

Has anybody heard of gravity? (Newton's Fourth Law.)

OK, we understand production costs, and allow you to use artificial gravity...

...but let us remember the “future of manned space flight” music video (i.e. the movie *2001*).



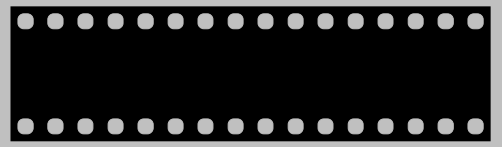
Note : the gravity in the moon shuttle is zero not because they're “in space” – it's zero because they're in *free fall*.

Newton's Law of Universal Gravitation

The gravitational force between two objects is:

- smaller with greater distance,
- proportional to the two objects' masses, and
- communicated at infinite speed.

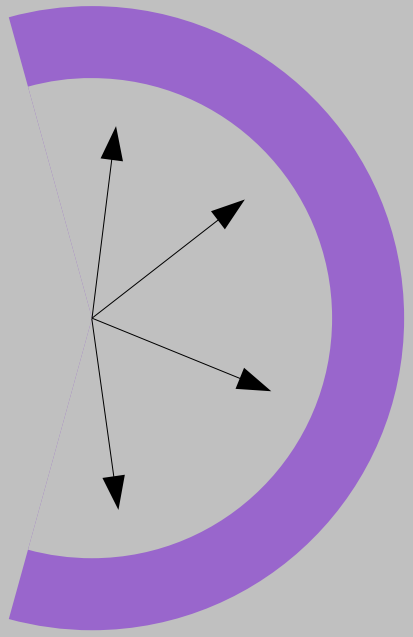
(Einstein's relativity tells us that the last one is wrong, and the first two are only approximately right, but this talk is about *Newtonian* physics....)



Star of mass M

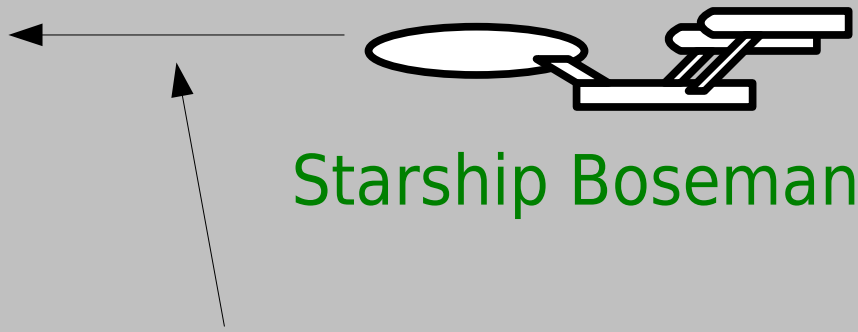
Gravity due to star

Starship Boseman



Expanding gas cloud
of mass M

Gravity due to gas cloud



Starship Boseman

Same Exact Force!!!

(And, anyway, we also know that gravity propagates at only the speed of light...)

B5: “And the Sky Full of Stars”

"If they dumped the body out of an airlock, the station's gravity wouldn't let it get far."

Do I need any more nerd cred?

Just in case : we can conclude that the airlock was *not* on the rotating section of the station.

From a 1994/03/22 post to `alt.tv.babylon-5`

The mass of the station is 2.5 megatons (is that right?), or (for us metric weenies) 2.3x10^9 kg. I am going to assume that the people and equipment inside it don't effect this by more than a factor of two.

The station is 5 miles long; I haven't found a reference to the diameter, but the aspect ratio looks like about 1:10, so call it 1/4 mile radius, or 400m

Escape velocity is sqrt(2*G*M/r). You can get this by equating the kinetic energy of an object moving with velocity v to the potential energy of the same object at radius r from the center of mass M.

For these numbers I've pulled up, escape velocity is:

v=sqrt(2 {6.67e-11 m^3/(kg s^2)} {2.3e9 kg} / {400 m})

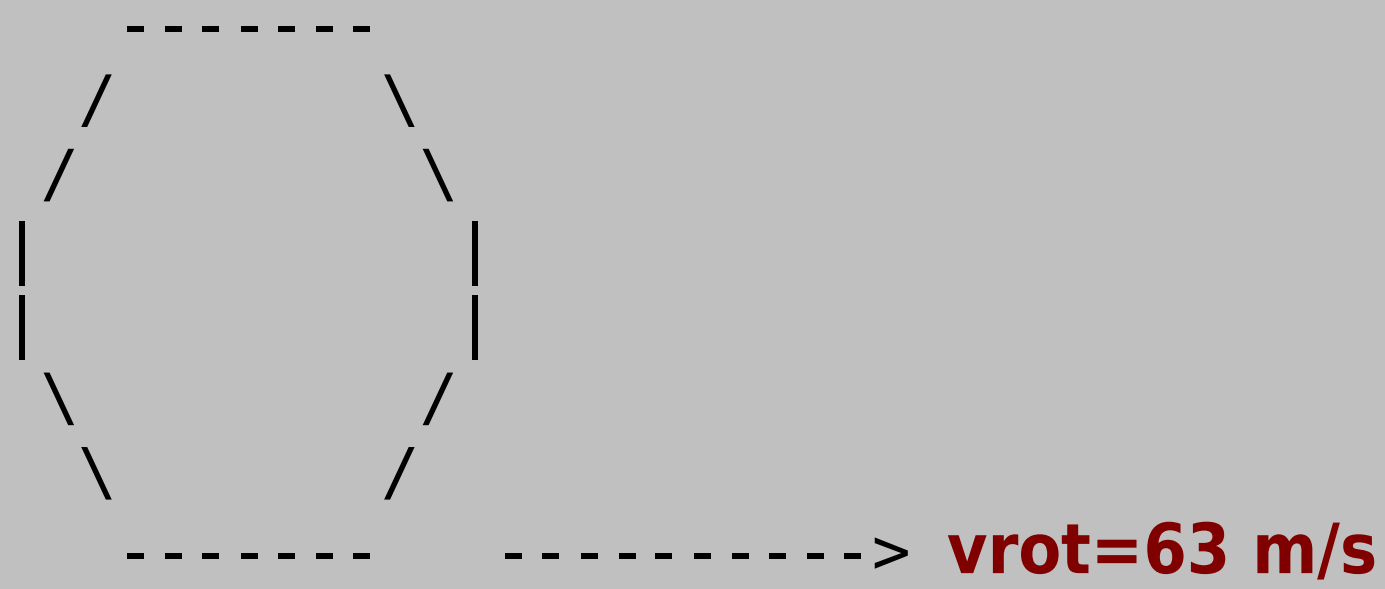
v~=.03 m/s

(I did assume spherical symmetry, but this is back-of-the-envelope stuff.)

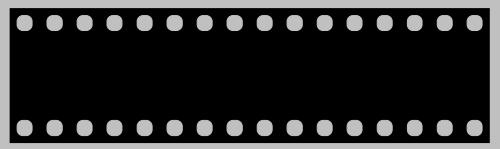
Now, consider the station's rotation. To obtain 1 earth gravity of about 10 m/s^2 at the outside of the station, it requires a rotational velocity of sqrt(g*r) :

vrot = sqrt(10 m/s^2 * 400m) = 63 m/s

which is _easily_ enough to send the body flying away from the station-- again, assuming that the body is just "dropped" from the station, and thus likely has the tangential velocity of the edge of the station:



Let's turn some superheroes into **PASTE**!



Free-fall for 15 seconds : speed=2400 mph

Terminal velocity for a person: ~150 mph

Batman has a cape; not unfurled, but it will help a *bit*...

Paste. Or at least broken.

...but sometimes, superheroes do nod to Sir Isaac...