Revision Sheet - PHY312 - midterm Tuesday

- Well away from gravitating matter possible to define special frames of reference - **inertial frames** in which free particles travel at uniform velocity.
- All observers in such frames should be equivalent as far as the laws of physics are concerned - principle of special relativity (SR).
- Speed of light is a fundamental constant $c \sim 3 \times 10^8 m/s$ as measured by all such observers.
- Different observers will ascribe different sets of coordinates (x, t) to same physical **event**. But all such (inertial) observers will agree on the spacetime interval $\Delta s^2 = c^2 \Delta t^2 - \Delta x^2$. This generalizes the concept of length to spacetime.
- Free particles move along straight worldlines such that their proper time is greatest.
- Time dilation formula - time measured on a moving clock is always greater than that measured in a frame in which the clock is stationary.
- Length contraction formula. Length is always greatest in a frame in which the object is at rest.
- Lorentz transformations. Allow you to go explicitly between (x, t) and (x', t'). Know the formula and how to apply it.
- Relativistic addition of velocities. Know the formula and how to apply it.
- Know what characterizes a spacelike, timelike and null spacetime interval. What is proper time ?
- Definition of the energy-momentum vector $P = (E/c, p)$ and formulae for relativistic energy E and (spatial) momentum p.
- Mass in SR. Rest mass is length of energy-momentum vector.
- Conservation of energy-momentum.
- Close to gravitating matter free fall frames play an important role - principle of equivalence states that they cannot be distinguished locally from inertial frames (also equivalent to equality of gravitational and inertial mass and the fact that all (test) bodies accelerate at the same rate in a gravitational field)
- GR is founded on this idea together with the principle of general relativity - all frames should be equally good for describing the physical world - even accelerating ones!
- However gravity can not be entirely eliminated by going to a FFF - tidal effects.
- Tidal effects arise when gravitational field varies in space.

Know how to ...

- Calculate spacetime interval from spatial and temporal separations in a FOR.
- Know how to use Lorentz transformations to calculate (t, x) from (t', x') and how these 2 FOR move relative to each other.
- Know how to add velocities. Firing a bullet from some FOR which is traveling with respect to us. What is its speed relative to us ?
- Travel to stars problems. Eg how fast would rocket have to go to reach star X which is a certain distance away from us. How much elapses back on Earth. Time dilation ...
- Calculate E,p for relativistic particle. Eg $E = \gamma mc^2$, $p = \gamma mv$ where m is rest mass. Know how to calculate the total mass of a relativistic system from $(E/c)^2 - p^2 = m^2c^2$. Masses DO NOT add in relativity.
- Simple conservation of E,p problems. Eg stationary atom emits photon of certain energy.
- Know how E,p change on going from one FOR to another – (E/c,p) transform like (ct,x) under lorentz transformations. What is energy of atom after ? Momentum of photon ?
- Tidal gravity problems. Eg the ball bearings in the falling elevator – new separations proportional to gravitational acceleration, initial separation, time of fall ...