EP 207: Introduction to Special Theory of Relativity
Tutorial 2 - Mechanics

Q1: A particle of rest mass m and speed v collides and sticks to a stationary particle of mass M. What is the final speed of the composite particle?

Q2: a) Starting from $dT = Fdx = \frac{dp}{dt}dx$ show that $dT = \gamma^3 m_0 c^2 \beta d\beta$ and thus $T = m_0 c^2[\gamma - 1]$ ($p = \gamma m_0 v$)
b) At low velocities what can T be approximated by?

Q3: The K^0 meson decays into two charged pions according to

$$K^0 \rightarrow \pi^+ + \pi^-$$

(pions have equal and opposite charges as indicated and same rest mass $m_\pi = 140 MeV/c^2$.)
A K^0 at rest decays into two pions in a bubble chamber with a magnetic field of 2.0 T.
If the radius of curvature of the pions is 34.4 cm, determine the momenta and speeds of the pions and the rest mass of the K^0.
Use: p=eBR where e is charge of e^-, p is momentum, B is magnetic field and R is radius of curvature

Q4: Suppose a planet is one light-year away from earth.
a) How fast must one travel to reach it in one day?
b) What is the gain in kinetic energy in terms of the rest-mass of the space-ship?

Q5: A stationary target proton is struck by another proton that moves along the +x-axis with $1 GeV$ kinetic energy in the laboratory frame. The proton rest mass is $940 MeV/c^2$.
a) Find the velocity of the center of mass. b) What is the kinetic energy of the target proton in the center-of-mass system. [from Basic Relativity - Richard Mould]

Q6: The rest masses of a proton, a neutron and a deuteron nucleus are $1.00731, 1.00867$ and $2.01360 a.m.u.$ respectively. What is the minimum energy required to split a deuteron into a proton and a neutron?

Q7: The heat of combustion of diesel is $44.80 MJ/kg$. If one kg of diesel is burnt (with a corresponding amount of oxygen) what is the loss in mass? If the combustion takes place in isolation where exactly does the mass go?