Work, energy and power

(Take 9 = 9.8 Nkg^{-1} where needed)

1. A lift has a mass of 400 kg. A man of mass 70 kg stands on a weighing machine fixed to the floor of the lift. Four seconds after starting from rest the lift has reached its maximum speed and has risen 5 m.
   (a) What will be the reading on the weighing machine during the period of acceleration?
   (b) How may it be decided whether the acceleration was uniform?
   (c) How much energy will be used by the lift motor in (i) the first four seconds, (ii) the next four seconds?

2. A dummy is used in a test crash to test the suitability of a seat belt. If the dummy had a mass of 65 kg and it was brought to rest in a distance of 65 cm from a velocity of 12 ms^{-1} calculate
   (a) The mean deceleration during the crash, and
   (b) The average force exerted on the dummy during the crash.

3. In a colliding beams accelerator, two beams of protons travelling in opposite directions are made to collide head on. If the mass of a proton is 1.67 x 10^{-27} kg and the protons have been accelerated to an energy of 10 GeV, calculate the kinetic energy' in joules lost in the collision.
   Compare this with the energy available when a single proton of energy 10 GeV strikes a stationary target.

4. Two scale pans each of mass 12.0 g are connected together by a light string which passes over a friction-less pulley. A mass of 20 g is placed in one of the pans which then starts to move downwards. Calculate
   (a) The tension in the string,
   (b) The acceleration of the pans and
   (c) The force exerted by the 20 g mass on the scale pan.

5. A car travelling at 30 ms^{-1} along a level road is brought to rest in a distance of 35 m by its brakes. If the car has a mass of 900 kg calculate the average force exerted by the brakes
   If the same car travels up a slope of 1 in 15 at a constant speed of 25 ms^{-1} what power does the engine develop if the total frictional resistance is 120 N?

6. What is the maximum speed at which an earth-mover of mass 250 000 kg can descend a slope of 1 in 10 if the brakes can dissipate energy at a maximum rate of 2000 kW?

7. A rope tied to a trolley is pulled so that the trolley accelerates. However, according to Newton's third law, the trolley pulls back on the rope with an equal and opposite force.
(a) Is the total work done zero?
(b) If so how can the trolley's kinetic energy change?

8. The total annual energy consumption of the United States is of the order of 10^{19} J.
   (a) What area of solar collector would be needed to produce this energy', given that the power falling on the Earth's surface due to solar radiation is 1400 W m^{-2}? (Assume 100 per cent efficiency.)
   (b) What mass of deuterium would be required to supply that need?
   (Mass defect when two deuterium nuclei fuse to give one nucleus of helium = 0.0255 u
   1u = 1.66x10^{-27} kg
   Mass of a deuterium atom = 2.014u)

9. A lift is raised at a constant speed. Is the total work done on the lift positive, negative or zero?

10. A girl bounces on a trampoline getting higher and higher each time she bounces. How is she able to increase her total mechanical energy?

11. A gun is powered by a spring that requires a force of 500 N to compress it by 1 m. It is compressed by 0.05 m and a ball of mass 0.01 kg is put in the barrel against the compressed spring Calculate:
    (a) the maximum velocity with which the ball leaves the barrel when the gun is fired
    (b) the acceleration of the ball