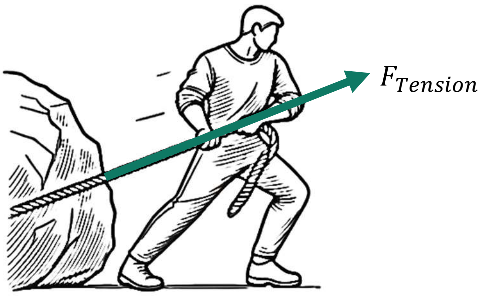
2.1 Mechanical Energy, Work and Power

Problems Worksheet

Step Up In Physics
Unit 1 and 2

1. A 68.0 kg mountaineer is carrying a 23.0 kg pack when she reaches the summit of Mount Everest, 8850 m above sea level. Calculate the potential energy of the mountaineer with her bag compared to at sea level.

2. A competitor in a strength competition is dragging a 75.0 kg boulder using a rope over a horizontal surface. The rope has 550 N of tension, angled at 15.0^0 above the horizontal.



Determine the work performed by the competitor on the rock after dragging the rock 12.0 m across the surface.

3. A fireman runs up a flight of emergency stairs. There are 220 steps, each 18.0 cm high. He reaches the top in 2.50 minutes. Estimate the power exerted by the fireman. State any assumptions made.

4. The driver of a 1120 kg car falls asleep at the wheel while driving at 50.0 km h^{-1}. With his foot off the accelerator, the car rolls to a stop over 75.0 m, luckily staying on the road and avoiding all obstacles.

   a) Determine the initial kinetic energy of the car.

   b) Hence, determine the frictional force acting on the car that brought it to a stop.

5. The brakes on a 12.0 kg bike moving at 8.05 m s^{-1} do 935 J of work on the bike and its rider. The cyclist on the bike has a 55.0 kg mass. Determine the final speed of the bike.

6. Clarissa pushes a 16.0 kg box across a horizontal floor at a constant velocity. The coefficient of kinetic friction between the box and floor is 0.48.

   a) Determine the work per metre performed by Clarissa to maintain the box's velocity. Give your answer with an appropriate unit for your calculated quantity.

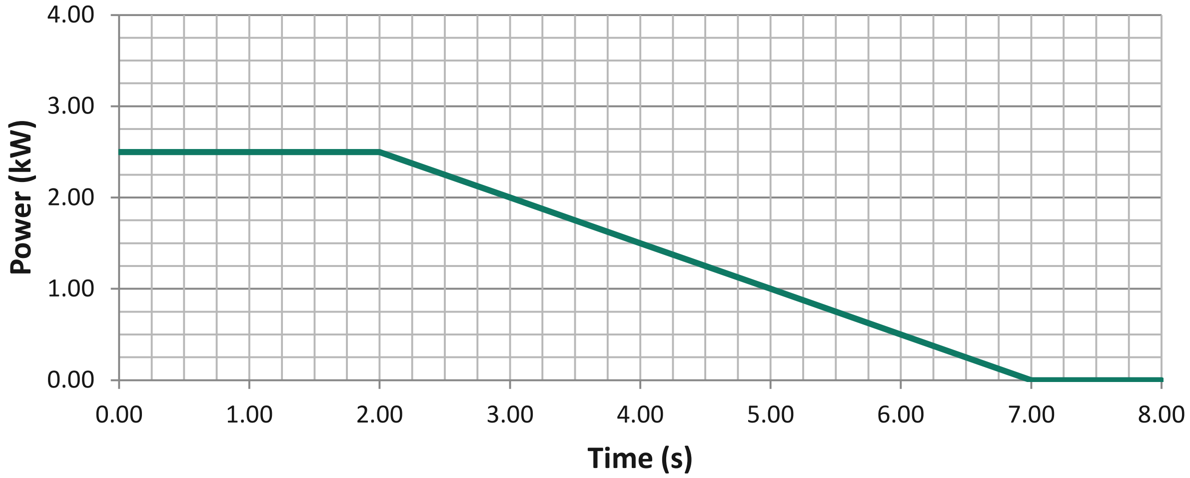
   b) Work is defined as the change in energy ($W = \Delta E$). In this scenario, the kinetic energy of the box remains constant. Explain how work is still being done by Clarissa despite her not causing a change in the kinetic energy of the box.

7. A crane is slowly lifting a 120 kg girder from the ground to the top of a 26.0 m high rise building under construction. The process takes 1.80 minutes.

   a) Determine the work done by the crane and hence, the power of the crane.

   b) The girder was the wrong size. The crane operator slowly lowers the girder back to the ground. Justify whether the crane is doing any work as it lowers the girder.

8. The graph below shows how the power output of a 960 kg car starting from rest varies over time.



Assuming the engine is 100% efficient, determine the speed of the car after the 8.00 s shown in the graph. You may also assume there are negligible drag forces and the power is used to accelerate the car in a single direction.

9. A 60.0 kg cyclist on a 13.0 kg bike travelling at 26.0 km h^{-1} puts in some extra effort, causing a 0.300 m s^{-2} acceleration over a flat, 15.8 m stretch of road.

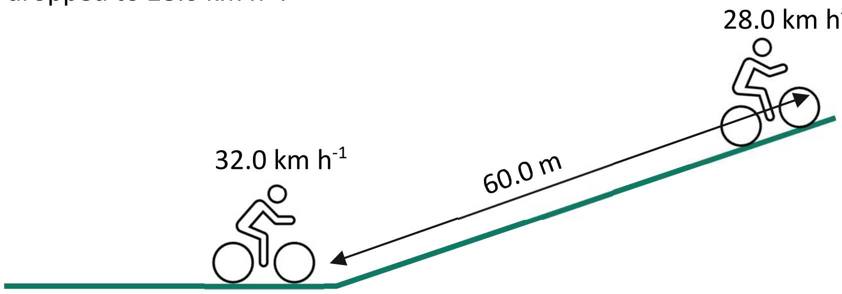
a) Calculate the work performed by the cyclist assuming there is insignificant air resistance or other drag forces.

b) Estimate the work performed by the cyclist knowing there is 85.0 N of drag forces acting on the cyclist before accelerating.

c) Hence, estimate the power of the cyclist required to create this acceleration.

d) Show through manipulation of formulae that it is necessary for the cyclist to increase their power output over time to maintain a constant acceleration (even if there is no air resistance or drag). Hint: relevant equations are $W = Fs$, $P = \frac{W}{\Delta t}$ and $v = \frac{s}{\Delta t}$.

10. A cyclist and her bike have a combined mass of 70.0 kg. She is approaching the base of a 12.0^0 incline at 32.0 km h^{-1}. She pedals harder while on the hill. Despite this, when she has travelled 60.0 m along the inclined surface, her speed has dropped to 28.0 km h^{-1}.



a) Determine her kinetic energy at the base of the incline.

b) Determine her total mechanical energy after she has travelled 60.0 m along the inclined surface.

c) Assuming a constant acceleration while on the incline, determine the time to ride 60.0 m along the inclined surface.

d) Hence, determine her average pedalling power during her ride up the incline.

