THE COPPERBELT UNIVERSITY
SCHOOL OF MATHEMATICS AND NATURAL SCIENCES
DEPARTMENT OF PHYSICS

PH 110 INTRODUCTORY PHYSICS

TUTORIAL SHEET 5_2024: WORK, POWER AND ENERGY

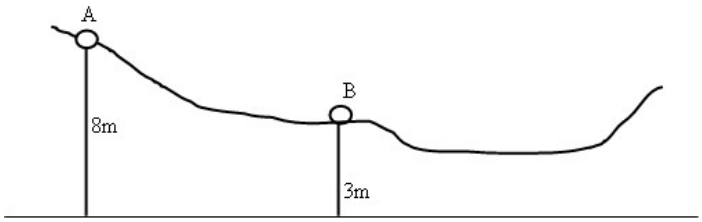
1. A car is moving at a speed of 20 m/s on a level ground when its brakes are applied. If it skids for 32.0 m before stopping what is the coefficient of kinetic friction between its tires and the road?

2. A force $\mathbf{F} = (6\mathbf{i} - 2\mathbf{j} + 5\mathbf{k})N$ acts on a particle that undergoes displacement $\mathbf{s} = (3\mathbf{i} + \mathbf{j} + 4\mathbf{k})\ m$. Find (a) the work done by the force on the particle and (b) the angle between $\mathbf{F}$ and $\mathbf{s}$.

3. A 15-kg block is dragged over a rough, horizontal surface by a constant force of 70 N acting at an angle of 30˚ above the horizontal. The block is displaced 5 m, and the coefficient of kinetic friction is 0.3. Find the work done by (a) the 70-N force, (b) the force of friction, (c) the normal force, and (d) the force of gravity. (e) What is the net work done on the block?

4. A 2 kg block starts to slide up a 20º incline with an initial speed of 200cm/s. It stops after sliding 37 cm and slides back down. Assuming the friction force impeding its motion to be constant, (a) how large is the friction force, and (b) what is the block's speed as it reaches the bottom?

5. A roller coaster car of mass 400 kg starts from rest at point A and passes the point B with a speed of 3 m/s. If the distance from A to B along the tracks is 20 m, how large is the average friction force retarding the motion of the car.

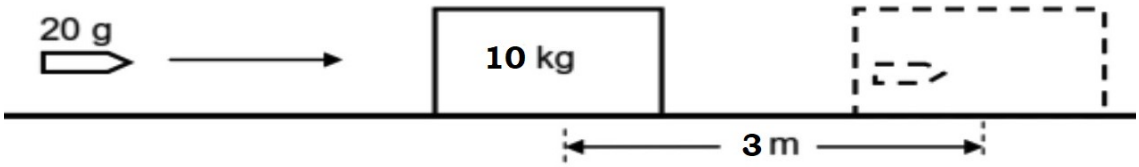


6. A crate of mass 10 kg is pulled up a rough incline with an initial speed of 3 m/s. The pulling force is 250 N parallel to the incline, which makes an angle of 30° with the horizontal. The coefficient of kinetic friction is 0.500 and the crate is pulled 5.00 m.
   (i) How much work is done by gravity?
   (ii) How much energy is lost due to friction?
   (iii) How much work is done by the 250 N force?
   (iv) What is the change in kinetic energy of the crate?
   (v) What is the speed of the crate after being pulled 5.00 m?

7. The diagram below shows an elevator that has a mass of 1500 kg and carries passengers having a combined mass of 1000 kg. A constant frictional force of 5000 N retards its motion upward.

a) Draw a well labelled free diagram showing all the forces that act on the lift.
b) Determine the power delivered by the motor to lift the elevator at a constant speed of 4 m/s

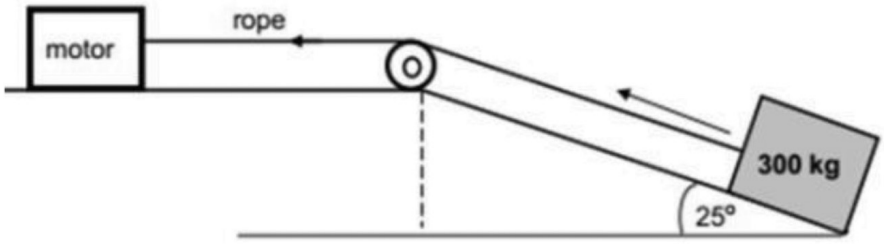
8. Figure 1.2 shows a bullet of mass 20g travelling horizontally to the right. The bullet strikes a stationary 10 kg block and becomes embedded in it. The bullet and the block together travel on a rough horizontal surface for a distance of 3 m before coming to as stop.



(i) Prove the work energy theorem

(ii) Use the work energy theorem to calculate the magnitude of the velocity of the block the bullet-block system immediately after the bullet strikes the block, given that the friction force between the block and the surface is 15 N.

9. A motor pulls a crate with a mass of 300kg with a constant force by means of a light inextensible rope running over a light frictionless pulley, as shown below. The coefficient of kinetic friction between the crate and the surface of the inclined plane is 0.20.



(i) Calculate the magnitude of the frictional force acting between the crate and the surface of the inclined plane.
(ii) The crate moves up the incline at a constant 1.5 m/s. Calculate the average power delivered by the motor while pulling the crate up the incline.

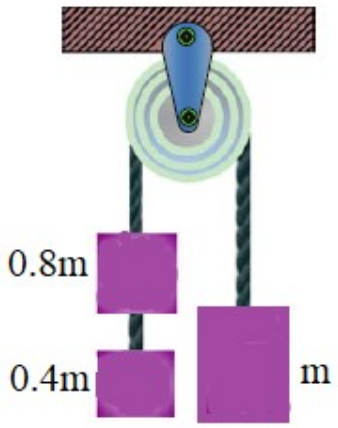
10. A bullet weighing 50 grams is fired with a velocity 400 m/s. It passes through a window pane 2 mm thick and its velocity is reduced to 200 m/s. Using work-energy theorem, calculate the force applied on the bullet by the window pane.

11. An engine pumps 2 tons of water in one minute to an average height of 10 m. Calculate the power of the engine if 30% of the energy is wasted in the process.

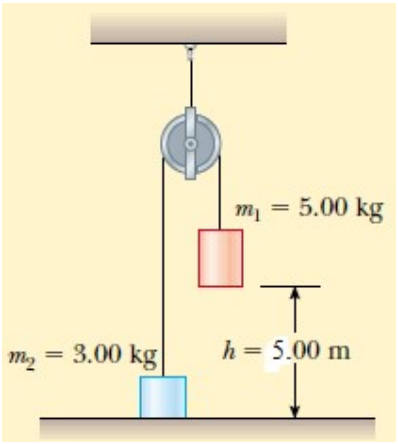
12. A pump on the ground floor of a building can pump up water to fill a tank of volume $30cm^3$ in 30 minutes, if the tank is 40m above ground and efficiency of the pump is 40%. How much electric power is consumed by the pump?

13. A 1500-kg car accelerates uniformly from rest to a speed of 10 m/s in 3 s. Find (a) the work done on the car in this time, (b) the average power delivered by the engine in the first 3 s, and (c) the instantaneous power delivered by the engine at $t = 2\,s$.

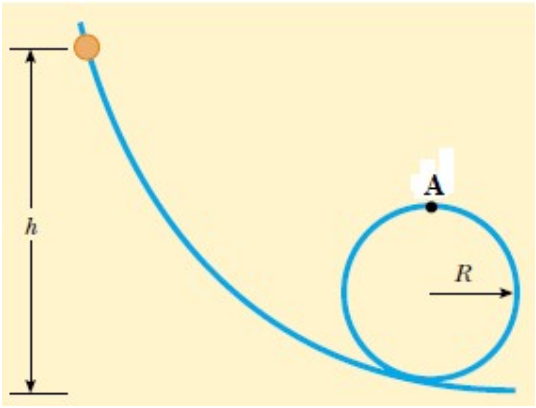
14. Three masses are connected as shown in the figure below over a frictionless pulley and the system is released from rest. After the object with mass m has risen a height of 81 cm, the object of mass 0.5m falls off from the system. What would be the speed of the mass m as it returns to its original position? Ignore air resistance.



15. Two bodies are connected by a string that passes over a pulley, as shown in the below. The lighter body is resting on the floor and the other is held in place a distance of 5.0 m from the floor. The heavier body is then released. Calculate the speeds of the two bodies as the heavy mass is about to hit the floor.



16. A bead slides without friction around a loop-the-hoop. The bead is released from a height $h = 3.50R$. (a) what is its speed at point A?(b) How large is the normal force on it if its mass is 5.00 g.



17. During a fire-extinguishing operation, a helicopter remains stationary (hovers) above a dam while filling a bucket with water. The bucket, with a mass of 60kg, is filled with 1 500kg of water. It is lifted vertically upwards through a height of 30m by a cable, at a **constant speed** of 2 $m \cdot s^{-1}$. The tension in the cable is 18 000N. Assume that there is no sideways motion during the lift. Air friction is NOT ignored.

(i) Draw a labelled free-body diagram showing ALL the forces acting on the bucket of water, while it is being lifted upwards.

(ii) Use the **work-energy theorem** to calculate the work done by air friction on the bucket of water after moving through the height of 30 m.