Work Energy and Power

Question

So what we have is a cord that is used to vertically lower a stationary block of mass M at a constant downward acceleration of g/4. And the questions are:

When the block has fallen a distance d, find:

a) the work done by the cord's force on the block

b) the work done by the gravitational force on the block

c) the kinetic energy of the block

d) the speed of the block

Solution:

Now this is one of those questions that bring about conceptual clarity of a topic… and therefore I would like you all to listen to this one carefully.

So step 1 is to understand the forces acting on the box.

We will denote the magnitude of the force of the cord on the block as F, which obviously acts upward, opposing the force of gravity and causing an acceleration g/4 downward (instead of g that would have happened if it was not present)

Let's take the upward direction as positive, then according to Newton's second law:

$F_{net} = ma$ or

$-Mg + F = M(-g/4)$

…and solving for F, we get

$F = (3/4)Mg$

So, the force F of the cord is (3/4)Mg, acting upward.

a) So the first question is the work done by the cord's force

Since the displacement is downward and the force is upwards, the work done by the cord's force should be negative or

$W_F = -F * d$

Now, you could have also used the formula Work done = F.d = Fd cos(180°) = Fd(-1) to arrive at this. In fact, I would say this is a more proper way of finding the work done by the cord's force.

So this gives us: $W_F = -(3/4)\,Mgd$

b) Next, we have to find the work done by the gravitational force

We can write work done by gravitational force as:

$W_g = F_g * d$ or

$W_g = Mg\, d$

c) The next question is what is the total work done on the block

Now this is an easy one and we can say that the total work done on the block is the sum of the works done by the cord's force and the gravitational force or

$W_{net} = W_F + W_g$ or

$W_{net} = -(3/4)Mgd + Mgd$ or

$W_{net} = (1/4)Mgd$

d) Next we are asked to find the kinetic energy of the block once it has moved distance d

To find this, we will make use of the work-energy theorem that says the total work done on the block should equal its change in kinetic energy:

$K_f - K_i = W_{total}$

Since the block starts from rest, its initial kinetic energy is zero and therefore

$K_f = (1/4)Mgd$

e) …and the last question is the speed of the block

Here, we use the kinetic energy formula $K = (1/2)Mv^2$ to find the speed v of the block: $(1/2)Mv^2 = (1/4)Mgd$

Solving for v, we get: $v = \sqrt{(gd/2)}$