PHYS1110D – Engineering Physics: Mechanics and Thermodynamics

Tutorial Problems for Week 6: Kinetic and Potential Energy

**Problem 1 – Work**

A picture containing clock

Description automatically generatedA block with mass is suspended vertically on a non-stretching rope (i.e. its length will not change) of length . Now, we apply a varying *horizontal* force on the block, and move it to a final position, in which the rope forms an angle of 30 to the vertical direction (see the figure). Neglecting the mass of the string, please:

1. Find the magnitude of the force required to maintain the block at the final position;
2. Calculate the work done on the block: (*Be careful about these two questions*)
   1. by the tension in the rope.
   2. by the horizontal force ;

A picture containing clock

Description automatically generated**Solution:**

1. From force diagram, we have
2. The work done by a force is given by
   1. During the whole process, is perpendicular to all the time, so the tension does *zero work.*
   2. Method 1: The work done by is converted to the increase in the potential energy of the block. Therefore

Method 2: Using the definition

*Question: Can you see why the component of in the direction of is ?*

![A picture containing object, clock, table, mirror

Description automatically generated]()**Problem 2 – Conservation of Energy Applied to Old Problems**

Block A (mass ) and B (mass ) are tied to a rope hanging over through two pulleys. Neglecting all frictions and the mass of the pulleys, try using conservation of energy to find the acceleration of block A (specify both its magnitude and direction, ).

**Solution:**

Now that you are a grown-up adult in the University, we advise you to use energy arguments instead of the old free-body diagram to solve such “ideal” problems with no disgusting frictions.

Suppose that A drops a distance starting from time . Obviously

are the speed and (magnitude of) the acceleration of the two blocks.

The system has constant total mechanical energy. Its value is

Here we choose the initial configuration to have zero potential energy. Take the time derivative of the energy, we get

Or

Crossing out the common factor , the magnitude of the acceleration is

**Problem 3 – From Potential Energy to Force**

A particle moving on the -axis has potential energy (unit: Joule; unit of : meter)

1. What is the force on this particle at position ? Please specify the direction of the force.
2. Suppose the particle is initially at position with zero velocity. What is the minimum kinetic energy required for the particle to be able to reach ?

**Solution:**

**Problem 4 – From Force to Potential Energy**

The restoring force of a spring is given by where and are in meters and Newtons respectively.

1. Find the work done required to compress the spring by 1 m. Express your answer in terms of and .
2. A block with mass of 2 kg is attached to a spring with restoring force of where and are in meters and Newtons respectively. An external force of 164 N acts on the block to compress the spring.
   1. Calculate the change in length of the spring.
   2. If the external force is now removed and the mass is now released from rest. Find the maximum speed that will be experienced by the mass.

**Solution:**

1. Work done required is
2. a)

So, the spring is compressed by 1 m.

b) The mass attains its maximum speed when all of the potential energy of the spring is converted into kinetic energy of the mass. It happens when the spring is at its natural length. Therefore, by the result of (a),

**Problem 5 – Conservative or Not?**

A force given by   acts on an object moving on the *x-y* plane. Find the work done on the object by the fore if

1. it moves from (0,0) to (1,0) on a straight line. And then to (1,1), on a straight line.
2. it moves from (0,0) to (0,1), on a straight line. And then to (1,1), on a straight line.

Then conclude whether is a conservative force or not.

A picture containing object, clock

Description automatically generated**Solution:**

1. When it moves along a straight line from (0,0) to (1,0),

When it moves along a straight line from (1,0) to (1,1),

So, the total work done is 1 J.

1. When it moves along a straight line from (0,0) to (0,1),

When it moves along a straight line from (0,1) to (1,1),

So, the total work done is 0, which is different from the answer in (1).

As the integral is path-dependent, the force is non-conservative.