

School of Physics

**Mechanics - 2. Work, Energy**

**(for PHS1011/ENG1802)**

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*Designed to identify wrong ideas and help understanding of basic concepts in physics.*



***Keep the answer page covered****. while doing questions. Use g = 10 ms-2 when required.*

1. In each of the diagrams above, how much work is done by the force labelled **F** in moving 0.2m in the direction shown by **d** ? In each case, F = 15 N and d = 0.2 m.

Answers: a) \_\_\_\_\_\_ b) \_\_\_\_\_\_ c) \_\_\_\_\_\_ d) \_\_\_\_\_\_

e) Give an example of the situation shown in (d).



2. Two identical blocks I and II are released from rest from the same height and slide down two tracks as shown above. Both tracks start and end at the same level. Friction may be neglected.

a) Which of the following is the same for both blocks at the bottom of the tracks?

A. speed B. kinetic energy C. momentum Answer: \_\_\_\_\_\_\_

b) Block II is replaced by block III having mass twice that of block I. Now, which of the above quantities are the same? Answer:\_\_\_\_\_\_\_\_

**DO NOT READ THIS PAGE UNTIL YOU COMPLET PAGE 1**

**Answers for page one**

1. (a) 3.0 N. The force **F** acts in the same direction as displacement **d** hence W = Fd.

(b) Zero. If you obtained a non-zero answer, you have overlooked the fact that **F** and **d** are at right angles, hence the work done is zero. Refer to the notes on part (c).

(c) 15 N x 0.2 x cos45̊ = 2.1 N. If you obtained 3.0 N, you may have overlooked the fact **F** and **d** are vector quantities, and the work depends on their relative directions. You should use the general expression *W=* **F**∙**d** = *Fd* cosθ where θ is the angle between **F** and **d.** Alternatively, take the component of **F** in the direction of **d**, which is *F*cosθ , then multiply by *d*.

(d) - 3.0 N. This is a case of negative work done by **F.** If you overlooked the negative sign, you need to refer to Part (c) above. In the situation shown the object could have been moving upwards, then the work done by **F** (gravity) would **decrease** the kinetic energy of the object.

(e) Gravity, acting down as an object moves upwards, as in (d). Another important example is friction; negative values are obtained for work is for a sliding object, when friction opposes motion.

2. (a) A, B. The kinetic energy is the same, and also the speed. The work done by external forces on the block, equals the block’s increase in kinetic energy. The work done by gravity is *mgh* where *h* is the vertical height. This quantity is the same for both blocks. Note that the normal or reaction force of the track on the block does no work because it is perpendicular to the displacement. Alternatively, the same facts may be expressed using Conservation of Energy. Both blocks lose the same potential energy (*mgh)*. Momentum is a vector quantity, and the direction of the two blocks are different.

(b) A. For blocks of different mass, the work done on block III is twice that done on block I hence at the end of the tracks, the kinetic energy of III is twice that of I. However, the speeds of both blocks will be the same. This is because both the work done and the kinetic energy is proportional to mass, *K* = ½*mv2* = *mgh* . The same applies, more directly, for objects falling freely under gravity. The blocks do not have the same momentum, as explained in 2(a), above.

More **Questions**

3. A passenger plane maintains a cruising speed of 540 km hr-1 (150 m s-1) while descending vertically 1200 m over a distance of 10 km. The percent change in kinetic energy of the plane is closest to which answer?

A. 110% B. 50% C. 25% D. 0%



4. What is the change in kinetic energy of a elastic ball of mass 0.2 kg between the positions referred to on the diagrams shown above? Neglect air resistance in all cases.

(a) Rebounding off a hard, solid wall, from position P to Q Answer:\_\_\_\_\_\_\_\_\_\_\_

(b) Falling vertically under gravity, from position P to Q Answer: \_\_\_\_\_\_\_\_\_\_

For (c)-(e), the ball is thrown through the air.

(c) From P to Q. Answer: \_\_\_\_\_\_\_\_\_\_

(d) From P to P'. Answer: \_\_\_\_\_\_\_\_\_\_

(e) From P' to Q. Answer: \_\_\_\_\_\_\_\_\_\_ Answer: \_\_\_\_\_\_\_\_\_\_

*If you have had difficulty with any of Q.1-4, now do Q.5. Otherwise, move to the next page.*



5. A child of mass 30 kg swings on a rope as shown, starting from rest at point P and passing through the lowest point of its swing at Q, and it rises 0.5m to the top of its swing.

(a)What is the child's change in potential energy between P and Q?

(b) What is the work done by the rope on the child between P and Q?

(c) What is the work done by gravity on the child between P and Q?

(d) What is the change in the child's kinetic energy between P and Q?

**Answers**

3. D. The passenger plane continues to fly at the same speed, so there is no change in kinetic energy. Be careful not to simply equate "work done" or "decrease in potential energy" with "increase in kinetic energy". This is correct **only** for the **net work done** which includes all forces (including friction etc).

4. (a) No change. An elastic ball rebounds from a wall (or other very heavy object) with the same speed.

(b) Increase in kinetic energy ΔK = mgh = 0.2 x 10 x 2.0 = 4.0 J

(c) ΔK = 0. The change in potential energy is zero since P and Q are at the same heights. Hence the kinetic energy is unchanged.

(d) ΔK = mgh = 0.2 x 10 x (-2.0) J = -4.0 J. Note that the kinetic energy decreases; the potential energy increases from P to P´.

(e) ΔK = mgh = 0.2 x 10 x 2.0 J = 4.0 J.

5. (a) Work done by gravity = *mgd* = 30x10x(0.5)= 150 J. Note that work done depends on the displacement in the direction of the force. The force of gravity is vertically down, of magnitude *mg,*  and the vertical displacement *d* in the direction of gravity is 0.5 m, not the distance moved (2.5m).

(b) The change in potential energy = *mgh* where *h* is the change of vertical height. In this case *h* = -0.5m.

Note that the following always holds:

**change in gravitational potential energy = - work done by gravity**

(c) The tension in the rope acts at right angles to the direction of movement hence the work done is zero .

(d) ΔK = work done by gravity = 150 J.

**Questions**



6. An ideal spring has a force-extension graph as shown, where *x* is the extension of the spring. For an extension of 0.1 m, the potential energy stored in the spring is 15 J.

(a) What is the size of the force at *x* = 0.1 m ?

(b) What is the potential energy stored for an extension of 0.2 m ?

(c) Starting from its normal length, the spring is compressed by hand by 0.1 m. How much work is done by the hand on the spring?

(d) Starting from its normal length, the spring is extended by hand by 0.1m then slowly returned to its original length. What is the net work done by the hand?

A. 15 J B. 30 J C. - 15 J D. 0 J

7. Two cars have identical engines. Car II has a total mass, including its driver and load, equal to twice that of car I. Both cars start from rest and the same accelerating force is applied to each car via the driving wheels. Friction may be neglected.

a) After each car has travelled 5 m, what is the ratio



b) After each car has travelled 5 m, what is the ratio



**Answers**

6. (a) 300 N. The energy stored equals the area under the *F - x* graph, ie. the area of a triangle of base *x* = 0.1 m and height *F* . Therefore ½*Fx* = 15 J, so that *F* = 15x2/0.1 = 300 N.

(b) 60 J. The stored energy is equal to the area under the graph. By doubling the extension, the force (at maximum extension) is doubled, hence the total area is increased by a factor of 4. (Alternatively, potential energy = ½kx2 where x is the extension.)

(c) 15 J. Compression means that x is negative, and in this case x = -0.1 m in terms of the spring. The work done by the hand on the spring is ½(max.force)(displacement) = ½(-kx)(-x). This is identical to the stored energy in the spring for this case, which also equals the stored energy for extension in the original data.

(d) D: 0 J. As the spring returns to its original position, and the spring is elastic, the net work is zero. There is no changed in potential energy of the spring, nor is there any increase in kinetic energy. Alternatively, one can consider the *F - x* straight line graph above. The work done in extending to 0.1m is 15 J; the work done as the spring is allowed to return to its original length is -15 J, because the force by the hand is still in the +x direction, but the displacement is in the -x direction.

7. (a) Ratio = 1. The kinetic energies are the same, since the work done by the driving force equals Force x displacement, which is the same for both cars.

(b) Ratio = √2. The kinetic energies are the same, hence *vI*2/*vII*2 = *mII*/*mI*  = 2.