Step-by-step Process of Solving

Work and Power Problems

[Chapter](https://openstax.org/books/college-physics/pages/7-introduction-to-work-energy-and-energy-resources) 7

**This handout contains selected problems with**

* **step-by-step solutions**

**and**

* **the demonstration of the thinking process involved in problem-solving.**

# 1

*How much work does a supermarket checkout attendant do on a can of soup he pushes 0.600 m horizontally with a force of 5.00 N? Express your answer in joules and kilocalories.*

# Step 1

Read the problem again and highlight main information: what is known and what is unknown.

Check that all quantities have SI units of measurements.

If not, convert to SI units before calculations.

*How much work does a supermarket checkout attendant do on a can of soup he pushes 0.600 m horizontally with a force of 5.00 N?*

 *Express your answer in joules and kilocalories.*

Known: force and distance.

‘horizontally’ – means that the angle between force and distance is zero degrees.

Unknown: work.

# Step 2

Think about what formula to use.

Work

$W= F x d x\cos((angle))$,

$W$ is work, SI unit is Joule (J)

$F$ is force, SI unit is Newton (N)

$d$ is distance, SI unit is meter (m)

In our case angle = 0.

# Step 3

Substitute numbers into formula and calculate.

|  |  |
| --- | --- |
| Solution |  |

We use the fact that 1 kcal = 4186 J.

# 2

*A 75.0-kg person climbs stairs, gaining 2.50 meters in height. Find the work done to accomplish this task.*

# Step 1

Read the problem again and highlight main information: what is known and what is unknown.

Check that all quantities have SI units of measurements.

If not, convert to SI units before calculations.

*A 75.0-kg person climbs stairs, gaining 2.50 meters in height. Find the work done to accomplish this task.*

Known: mass and height.

Unknown: work.

Note: all physics quantities are in SI units.

# Step 2

Think about what formula to use.

Work

$W= F x d$,

$W$ is work, SI unit is Joule (J)

$F$ is force, SI unit is Newton (N)

$d$ is distance, SI unit is meter (m)

# Step 3

Substitute numbers into formula and calculate.

|  |  |
| --- | --- |
| Solution |  |

# 9

# *Compare the kinetic energy of a 20,000-kg truck moving at 110 km/h with that of an 80.0-kg astronaut in orbit moving at 27,500 km/h.*

# Step 1

Read the problem again and highlight main information: what is known and what is unknown.

Check that all quantities have SI units of measurements.

If not, convert to SI units before calculations.

*Compare the kinetic energy of a 20,000-kg truck moving at 110 km/h with that of an 80.0-kg astronaut in orbit moving at 27,500 km/h.*

Known: mass and speed of a truck; mass and speed of an astronaut.

Unknown: kinetic energy of both, a truck and an astronaut.

Note: speed in not in SI units. We need to convert to SI units, m/s.

# Step 2

Think about what formula to use.

Kinetic Energy

$KE= \frac{mv^{2}}{2}$,

$KE$ is kinetic energy, SI unit is Joule (J)

$m$ is mass, SI unit is kilogram (kg)

$v$ is speed, SI unit is meter per second (m/s)

# Step 3

Substitute numbers into formula and calculate.

|  |  |
| --- | --- |
| Solution |  |

# 17

*(a) How much gravitational potential energy (relative to the ground on which it is built) is stored in the Great Pyramid of Cheops, given that its mass is about  and its center of mass is 36.5 m above the surrounding ground? (b) How does this energy compare with the daily food intake of a person?*

# Step 1

Read the problem again and highlight main information: what is known and what is unknown.

Check that all quantities have SI units of measurements.

If not, convert to SI units before calculations.

1. *How much gravitational potential energy (relative to the ground on which it is built) is stored in the Great Pyramid of Cheops, given that its mass is about*  *and its center of mass is 36.5 m above the surrounding ground?*

Known: mass and the height of the center of gravity.

Unknown: gravitational potential energy.

Note: all quantities are in SI units.

*(b) How does this energy compare with the daily food intake of a person?*

# Step 2

Think about what formula to use.

Gravitational Potential Energy

$GPE=mgh$,

$GPE$ is gravitational potential energy

$m$ is mass

$g$ is acceleration due to gravity

$g=9.8 m/s$ on Earth

$h$ is the distance above zero level, usually above the ground level.

$h$ can be negative if an object is below the zero level.

# Step 3

Substitute numbers into formula and calculate.

|  |  |
| --- | --- |
| Solution | (a) (b)  |

We assume that average daily food intake of a person is 1.2 x 107 J.

# 38

1. *How long will it take an 850-kg car with a useful power output of 40.0 hp (1 hp = 746 W) to reach a speed of 15.0 m/s, neglecting friction? (b) How long will this acceleration take if the car also climbs a 3.00-m-high hill in the process?*

# Step 1

Read the problem again and highlight main information: what is known and what is unknown.

Check that all quantities have SI units of measurements.

If not, convert to SI units before calculations.

1. *How long will it take an 850-kg car with a useful power output of 40.0 hp (1 hp = 746 W) to reach a speed of 15.0 m/s, neglecting friction?*

Known: mass of the car, power of the car, speed of the car;

Force of friction is zero.

Unknown: time

Note: All quantities are in SI units but power. We need to convert hp into W.

Power = 40.0 hp x 746 W/hp = 29,840 W.

*(b) How long will this acceleration take if the car also climbs a 3.00-m-high hill in the process?*

Known: mass of the car, power of the car, speed of the car, the height;

Force of friction is zero.

Unknown: time

Note: All quantities are in SI units but power. We need to convert hp into W.

Power = 40.0 hp x 746 W/hp = 29,840 W.

# Step 2

Think about what formula to use.

1. By definition, power is

$$P= \frac{W}{t},$$

$P$ is power, SI unit is watt (W; 1 W = 1 J/s)

$W$ is work, in Joules (J)

$t$ is time, in seconds (s)

Let’s rearrange this formula for time, $t$

$t=\frac{W}{P}$.

1. Let’s recall Work-Energy theorem

$W= \frac{1}{2}mv^{2}-\frac{1}{2}mv\_{0}^{2}$,

$W$ is work, SI unit is Joule (J)

$m$ is mass, SI unit is kilogram (kg)

$v$ is final speed, SI unit is meter per second (m/s)

$v\_{0}$ is initial speed, SI unit is meter per second (m/s)

**This theorem will help us find work which we will then substitute into formula for time.**

# Step 3

Substitute numbers into formula and calculate.

The initial speed of the care is zero. The final speed of the car is 15.0 m/s.

So, work in this case is

$W=\frac{1}{2}mv^{2}$,

$v$ is final speed.

|  |  |
| --- | --- |
| Solution | (a) SolutionIn (b), we need to also consider the change in gravitational potential energy, because the height of the car changes.Gravitational Potential Energy$GPE=mgh$,$GPE$ is gravitational potential energy$m$ is mass$g$ is acceleration due to gravity$g=9.8 m/s$ on Earth$h$ is the distance above zero level, usually above the ground level. $h$ can be negative if an object is below the zero level. (b)  |