Physical sciences

Physics

Tutor

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Projectile Motions

- A projectile is an object that moves freely under the influence of gravity only. It is not controlled by any mechanism (pulley or motor). The object is in free fall, but may move upwards (thrown up) or downwards.
- Forces on a projectile In the absence of friction, the gravitational force of the Earth is the only force acting on a free falling body. This force always acts downwards. Because the gravitational force is always downward, a projectile that is moving upward, must slow down. When a projectile is moving downward, it moves in the direction of the gravitational force, therefore it will speed up.

- Acceleration due to gravity.
- All free-falling dies have the same acceleration, due to gravity. This **acceleration is 9,8 $\mathbf{m \cdot s^{-2}}$ downward**. Ignoring air resistance/ friction: if a marble and a rock are released from the same height at the same time, they will strike the ground simultaneously, and their final velocity will be the same. Their **momentum ($\boldsymbol{mv}$)** and **kinetic energy ($\boldsymbol{\frac{1}{2}mv^2}$)** are not the same, due to a difference in mass. If two objects are released from different heights, they have the same acceleration, but they strike the ground at different times and have different velocities.

Equations of motion

- $\overrightarrow{v_f} = \overrightarrow{v_i} + \vec{a}\Delta t$
- $\overrightarrow{v_f^2} = \overrightarrow{v_i^2} + 2\vec{a} \cdot \Delta\vec{y}$
- $\Delta\vec{y} = \overrightarrow{v_i}\Delta t + \frac{1}{2}\vec{a}\Delta t^2$
- $\Delta\vec{y} = \frac{\overrightarrow{v_1}+\overrightarrow{v_2}}{2} \times \Delta t$

Tips for calculations:

- Ignore air resistance for all calculations in Grade 12 unless the question states that there is air resistance.
- Free falling objects experience a constant downward acceleration equal to the gravitational acceleration, ($g = 9{,}8\ m \cdot s^{-2}$).
- Choose a direction (downwards or upwards) as positive and keep this unchanged throughout the problem.
- Indicate the direction you have chosen as positive clearly at the start of your answers.

- e.g 

Activity 1

- A ball of mass 200 g is dropped from the roof of a 100 m high building. Ignore air resistance and calculate:

1. the velocity of the ball when it hits the ground. (4)
2. how long the ball is in the air before it hits the ground. (5)

Solution:

1. $\overrightarrow{v_f} = \overrightarrow{v_i} + \vec{a}\Delta t$

   $= 0^2 + (2)(9{,}8)(100)$

   $= 1960$

$\overrightarrow{v_f} = \sqrt{1960} = +44.27\ m\ s^{-1}$, $\therefore\ 44.27\ m\ s^{-1}$; downwards

2. $\overrightarrow{v_f} = \overrightarrow{v_i} + \vec{a}\Delta t$

$44{,}27 = 0 + (9{,}8)\ \Delta t$

$\Delta t = \frac{44.27}{9.8} = 4.52\ s$

$\therefore$ the ball is in the air for 4.52 s

Practice questions

- A ball is thrown vertically upwards. Which ONE of the following physical quantities has a non-zero value at the instant the ball changes direction?

A. Acceleration

B. Momentum

C. Kinetic energy

D. Velocity

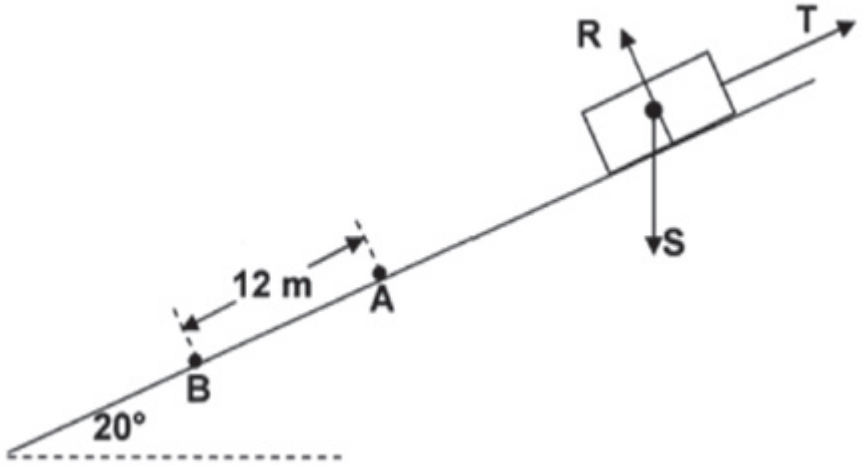
Revision of Grade 10

- Gravitational potential energy
$$E_p = mgh$$
- Isolated system (Closed system)
- Law of conservation of energy
- Mechanical energy (Em):
$$E_m = E_k + U$$
- Principle of conservation of mechanical energy.

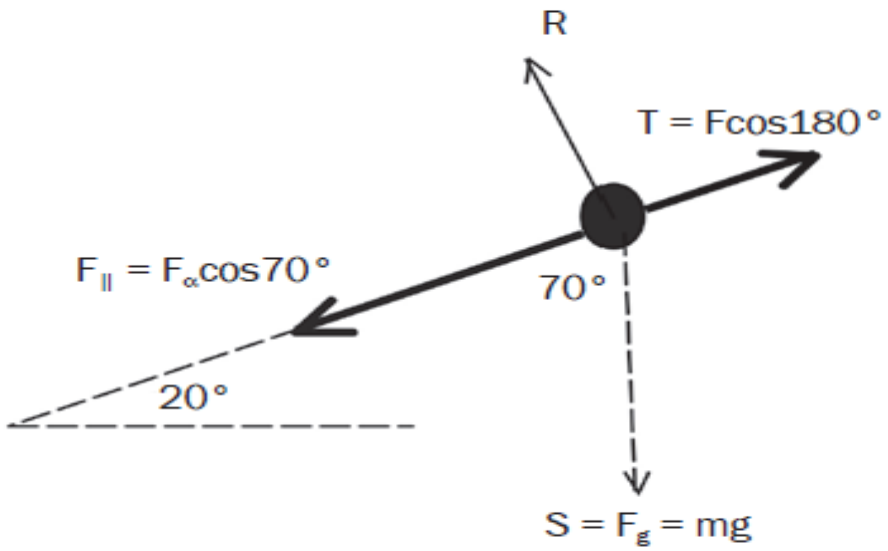
- The energy that an object has owing to its position in the Earth's gravitational field relative to a reference point.
- A system on which no external forces act (e.g. friction).
- Energy cannot be created or destroyed – it can only be transferred from one form to another.
- The sum of the gravitational potential energy and the kinetic energy of an object.
- The total mechanical energy in an isolated system remains constant.

Activity

- A crate of mass 70 kg slides down a rough incline that makes an angle of 20° with the horizontal, as shown in the diagram below. The crate experiences a constant frictional force of magnitude 190 N during its motion down the incline. The forces acting on the crate are represented by R, S, and T.



Solution

1. **R** is the Normal Force✓, **S** is the force of gravity✓ and **T** is the Frictional force✓
2. 

$W_{net} = F_g \Delta x \cdot \cos\theta + F_t \cdot \Delta x \cdot \cos\theta$ ✓

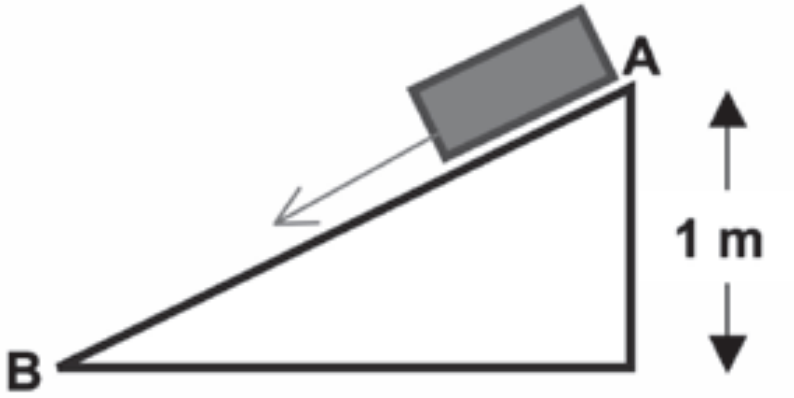
$W_{net} = (686)(12)(\cos 70^\circ)$ ✓ $+ (190)(12)(\cos 180^\circ)$ ✓

$W_{net} = 2815{,}51 - 2280$ ✓

$W_{net} = 535{,}51\ J$ ✓

Activity

- A box of mass 100 kg slides down a slope. Its velocity increases from 0 $m \cdot s^{-1}$ at point A to 4 $m \cdot s^{-1}$ at point B as in the diagram. Calculate the work done by the non-conservative force while it slides from A to B.



Solution

$W_{nc} = \Delta E_p + \Delta E_k$ ✓

$= [mgh_B - mgh_A] + [\frac{1}{2}mv_B^2 - \frac{1}{2}mv_A^2]$

$= [(100)(9,8)(0) - (100)(9,8)(1)]$ ✓ $+ [(\frac{1}{2})(100)(4)^2 - (\frac{1}{2})(100)(0)^2]$ ✓

$= -980 + 800 = 180$ J

$\therefore W_{friction}$ is 180 J ✓