Year 11 Physics | Momentum and Energy

Fundamentals of Mechanics — NESA Physics 11–12 Syllabus (2025)
Student practice worksheet

Name: _____ **Class:** _____ **Date:** _____

Instructions. Answer all questions, showing the relevant equation, substitution, calculation and final answer with units. Give directions for vector quantities. Unless otherwise stated, take $g = 9.80\,m\,s^{-2}$, assume a uniform gravitational field, neglect air resistance and use three significant figures where appropriate. In one-dimensional problems, choose a positive direction and use signed velocities. Diagrams may be drawn to support your answers. Questions become progressively more demanding.

Syllabus alignment. Focus area: *Fundamentals of mechanics*; section: *Momentum and energy*; knowledge outcome **PY-11-01**, with Working scientifically problem-solving, processing data and communicating outcomes.

A | Foundations

Question 1. Conservative and non-conservative forces

(a) State what is meant by a *conservative force*. (b) Identify whether gravity and kinetic friction are conservative or non-conservative forces. (c) State the condition under which the total mechanical energy of a system is conserved.

Question 2. Kinetic energy

A $1.50\,kg$ trolley moves along a level track at $4.00\,m\,s^{-1}$. Calculate its kinetic energy. Then calculate its kinetic energy if its speed doubles.

Question 3. Gravitational potential energy

A $3.00\,kg$ object is lifted vertically through $2.50\,m$ at constant speed. Calculate (a) the change in its gravitational potential energy and (b) the work done on the object by gravity.

Question 4. Work done at an angle

A student pulls a suitcase $5.00\,m$ horizontally with a constant $40.0\,N$ force at 60.0° above the horizontal. Calculate the work done by the pulling force.

Question 5. Momentum and impulse

A $0.250\,kg$ ball travels east at $12.0\,m\,s^{-1}$. (a) Calculate its momentum. (b) A net force brings it to rest in $0.150\,s$. Calculate the impulse on the ball and the average net force, including their directions.

B | Applying energy and momentum

Question 6. The work–kinetic-energy theorem

A $5.00\,kg$ trolley initially travels at $2.00\,m\,s^{-1}$ along a horizontal frictionless track. A constant horizontal net force of $15.0\,N$ acts in the direction of motion over $6.00\,m$. Determine the trolley's final speed using the work–kinetic-energy theorem.

Question 7. Energy gained on a climb

A $60.0\,kg$ cyclist and bicycle gain $12.0\,m$ in vertical height. (a) Calculate the increase in gravitational potential energy. (b) If the cyclist travels at constant speed, explain where this energy comes from.

Question 8. Vertical launch

A $0.400\,kg$ ball is projected vertically upwards at $14.0\,m\,s^{-1}$. Neglecting air resistance, calculate (a) its initial kinetic energy, (b) its maximum height above the release point and (c) its speed when it is $6.00\,m$ above the release point, while rising.

Question 9. Ramp with energy loss

A $2.00\,kg$ block starts from rest at the top of a ramp and descends through a vertical height of $3.00\,m$. Its speed at the bottom is $6.00\,m\,s^{-1}$. Calculate the energy transferred to thermal and other non-mechanical forms during the descent.

Question 10. Stopping a sliding object

A $4.00\,kg$ crate slides at $5.00\,m\,s^{-1}$ across a level floor. A constant kinetic friction force of $10.0\,N$ opposes its motion. Calculate the distance the crate travels before stopping using work and energy.

Question 11. Momentum versus kinetic energy

Two trolleys travel east. Trolley A has mass $2.00\,kg$ and speed $3.00\,m\,s^{-1}$; trolley B has mass $1.00\,kg$ and speed $6.00\,m\,s^{-1}$. Compare their momenta and kinetic energies. Explain why equal momenta do not necessarily imply equal kinetic energies.

C | Collisions and impulse

Question 12. Perfectly inelastic collision

A $0.600\,kg$ trolley travelling right at $3.00\,m\,s^{-1}$ collides with a stationary $0.400\,kg$ trolley. They stick together. Assuming negligible external horizontal impulse, calculate (a) their common velocity, (b) the total kinetic energy before and after the collision and (c) the kinetic energy transformed into other forms.

Question 13. Recoil

Two ice skaters, initially stationary, push apart on frictionless ice. Skater A has mass $50.0\,kg$ and moves east at $2.40\,m\,s^{-1}$. Find the velocity of skater B, whose mass is $75.0\,kg$, and explain why total momentum remains zero.

Question 14. Identical trolleys: elastic collision

A $0.500\,kg$ trolley moving right at $2.00\,m\,s^{-1}$ undergoes a one-dimensional *elastic* collision with an identical trolley initially at rest. Determine both final velocities. Show that momentum and kinetic energy are conserved.

Question 15. Unequal masses: elastic collision

A $2.00\,kg$ trolley moving right at $3.00\,m\,s^{-1}$ collides elastically, in one dimension, with a stationary $1.00\,kg$ trolley. Using conservation of momentum and the elastic-collision relationship, determine both final velocities.

Question 16. Classifying measured collisions

A $0.400\,kg$ trolley moving right at $3.00\,m\,s^{-1}$ collides with a stationary $0.200\,kg$ trolley. Two possible sets of post-collision measurements are shown below. For **each** set, calculate the total momentum and kinetic energy before and after, and classify the collision as elastic or inelastic.

Measurement set	Final velocity, trolley 1	Final velocity, trolley 2
A	$1.00\,m\,s^{-1}$ right	$4.00\,m\,s^{-1}$ right
B	$2.00\,m\,s^{-1}$ right	$2.00\,m\,s^{-1}$ right

Question 17. Ball rebounding from a floor

Take **upwards as positive**. A $0.150\,kg$ ball approaches a horizontal floor at $12.0\,m\,s^{-1}$ downwards and rebounds at $8.00\,m\,s^{-1}$ upwards. The contact lasts $0.0200\,s$. Calculate (a) the change in momentum and (b) the average **net** force on the ball during contact. (c) Calculate the average upward contact force exerted by the floor, allowing for the ball's weight.

D | Multi-step challenges

Question 18. Collision followed by an ascent

A $0.500\,kg$ trolley travelling right at $4.00\,m\,s^{-1}$ collides with a stationary $0.500\,kg$ trolley at the foot of a frictionless incline. The trolleys lock together and travel up the incline. Calculate (a) their speed immediately after impact, (b) the maximum vertical height they reach and (c) the total kinetic energy lost during the collision. Assume the collision occurs over a negligible distance.

Question 19. Force applied at an angle with friction

A $10.0\,kg$ crate, initially at rest, is pulled across a horizontal floor through $6.00\,m$ by a constant $50.0\,N$ force directed 30.0° above the horizontal. A constant kinetic friction force of $12.0\,N$ opposes the motion. Calculate (a) the work done by the applied force, (b) the work done by friction, (c) the net work and (d) the final speed. Assume that the crate remains in contact with the floor.

Question 20. Head-on elastic collision

On a frictionless track, a $2.00\,kg$ trolley moves right at $4.00\,m\,s^{-1}$ while a $1.00\,kg$ trolley moves left at $2.00\,m\,s^{-1}$. They collide elastically in one dimension. With right taken as positive, determine both final velocities. Verify conservation of both momentum and kinetic energy.

Question 21. Momentum in two dimensions

A stationary $6.00\,kg$ object breaks into three fragments due to an internal explosion on a frictionless horizontal surface. A $2.00\,kg$ fragment moves east at $3.00\,m\,s^{-1}$; a $1.00\,kg$ fragment moves north at $4.00\,m\,s^{-1}$. Determine (a) the velocity components of the third fragment, (b) its speed and (c) its direction measured south of west.

Question 22. An experimental collision and energy audit

A $0.500\,kg$ trolley moves right at $1.20\,m\,s^{-1}$ towards a stationary $0.300\,kg$ trolley. After collision, both move right at $0.750\,m\,s^{-1}$. (a) Test conservation of momentum using the data. (b) Determine the change in total kinetic energy and the percentage of initial kinetic energy converted into other forms. (c) Explain whether the data support an elastic or inelastic collision. (d) State one experimental factor that could cause a small apparent discrepancy in measured momentum.

Teacher note: Original practice material structured around the Momentum and energy section of the NESA Physics 11–12 Syllabus (2025); not an official NESA worksheet. Syllabus: https://curriculum.nsw.edu.au/learning-areas/science/physics-11-12-2025/content