INKPHYSICS FLASHCARDS

# Mechanics

Year 12 · 37 cards · fronts and backs

Print double-sided, flipping on the long edge, and each answer lands behind its question. Cut along the card borders.

Definitions in mark-scheme wording, the equations that are not on the data sheet, each lesson's check question, and the misconceptions that lose marks. The same cards run on the website with spaced-repetition scheduling, at inkphysics.co.uk/flashcards.

DEFINITION

Define: Scalar.

SCALARS AND VECTORS

DEFINITION

Define: Vector.

SCALARS AND VECTORS

CHECK YOURSELF

Forces of 30 N and 40 N act on a point at right angles to each other. Find the magnitude of the resultant and the angle it makes with the 30 N force.

Hint: Tip to tail, then Pythagoras for the size and tangent for the angle.

SCALARS AND VECTORS

SPOT THE ERROR

Say what is wrong with this claim:

Adding forces means adding the numbers.

SCALARS AND VECTORS

DEFINITION

Define: Moment of a force.

MOMENTS AND EQUILIBRIUM

DEFINITION

Define: Couple.

MOMENTS AND EQUILIBRIUM

DEFINITION

Define: Centre of mass.

MOMENTS AND EQUILIBRIUM

CHECK YOURSELF

A uniform 4.0 m beam of weight 200 N rests on supports at each end. A 600 N load sits 1.0 m from the left support. Find the force from the left support.

Hint: Take moments about the right support, so its unknown force vanishes.

MOMENTS AND EQUILIBRIUM

DEFINITION

A quantity with both magnitude and direction, such as velocity, displacement, force or momentum.

SCALARS AND VECTORS

DEFINITION

A quantity with magnitude only, such as speed, distance, energy or temperature.

SCALARS AND VECTORS

SPOT THE ERROR

Forces are vectors, so direction matters: 3 N and 4 N can make anything from 1 N to 7 N depending on the angle between them. Only components along the same line add as plain numbers.

SCALARS AND VECTORS

CHECK YOURSELF

Magnitude: $30^2 + 40^2 = 2500$, and the square root gives 50 N.

Direction: $\tan\theta = 40/30$, so $\theta = 53°$ to the 30 N force. A 3-4-5 triangle, which is why examiners are so fond of these numbers.

SCALARS AND VECTORS

DEFINITION

A pair of equal and opposite coplanar forces whose lines of action do not coincide.

MOMENTS AND EQUILIBRIUM

DEFINITION

The force multiplied by the perpendicular distance from the line of action of the force to the pivot.

MOMENTS AND EQUILIBRIUM

CHECK YOURSELF

About the right support: anticlockwise, $R_{left} \times 4.0$. Clockwise: the beam's weight, 200 N at its centre, 2.0 m away, gives 400 N m; the load, 600 N at 3.0 m from the right, gives 1800 N m.

So $4.0\ R_{left} = 400 + 1800 = 2200$, giving $R_{left} = 550$ N.

The pivot choice did the work: the right support's force never appeared, and one equation held one unknown.

MOMENTS AND EQUILIBRIUM

DEFINITION

The single point through which an object's weight can be taken to act.

MOMENTS AND EQUILIBRIUM

SPOT THE ERROR

Say what is wrong with this claim:

If the forces are equal, it balances.

MOMENTS AND EQUILIBRIUM

CHECK YOURSELF

A car brakes uniformly from 24 m $s^{-1}$ to rest over 60 m. How long does the braking take?

Hint: You know u, v and s. The quickest route uses the equation without a.

MOTION GRAPHS AND THE SUVAT EQUATIONS

SPOT THE ERROR

Say what is wrong with this claim:

SUVAT always works.

MOTION GRAPHS AND THE SUVAT EQUATIONS

CHECK YOURSELF

A ball rolls off a table 1.25 m high at 4.0 m $s^{-1}$. How long is it in the air, and how far from the table does it land? Take $g = 9.8$ m $s^{-2}$.

Hint: The fall time comes from the vertical motion alone; the sideways speed is irrelevant to it.

PROJECTILE MOTION

SPOT THE ERROR

Say what is wrong with this claim:

Something must keep pushing a projectile forwards.

PROJECTILE MOTION

CHECK YOURSELF

A book rests on a table. A student claims the book's weight and the table's normal contact force on it are a Newton's third law pair. Give two reasons the claim is wrong, and state the two genuine pairs.

Hint: Check the third law's small print: same type of force, different bodies.

NEWTON'S LAWS AND THE RESULTANT FORCE

SPOT THE ERROR

Say what is wrong with this claim:

Weight and the normal force are an action-reaction pair through the bar.

NEWTON'S LAWS AND THE RESULTANT FORCE

DEFINITION

Define: Mass.

MASS AND WEIGHT

CHECK YOURSELF

Using $s = 1/2(u + v)t$: $60 = 12 \times t$, so $t = 5.0$ s.

The same answer follows from $v = u + at$ once you find $a = -4.8$ m s$^{-2}$ from $v^2 = u^2 + 2as$; agreement between routes is the free check the four equations offer.

MOTION GRAPHS AND THE SUVAT EQUATIONS

SPOT THE ERROR

Equal forces can still turn an object: a couple has zero resultant force and a definite moment. Balance needs both resultant force and resultant moment to be zero.

MOMENTS AND EQUILIBRIUM

CHECK YOURSELF

Vertical: $s = 1/2gt^2$ with $s = 1.25$ m gives $t^2 = 2 \times 1.25 / 9.8 = 0.255$, so $t = 0.50$ s.

Horizontal: constant 4.0 m s$^{-1}$ for 0.50 s gives a range of $4.0 \times 0.50 = 2.0$ m.

Notice the order: the vertical problem produced the time, and the horizontal problem spent it.

PROJECTILE MOTION

SPOT THE ERROR

The SUVAT equations are derived assuming constant acceleration, so that is the only place they apply. When acceleration varies, the graphs still work: gradient and area never stop being true.

MOTION GRAPHS AND THE SUVAT EQUATIONS

CHECK YOURSELF

Both forces act on the same body, the book, and they are different types, gravitational and contact. A third-law pair fails on either count alone; this fails on both.

The genuine pairs: the Earth pulls the book down and the book pulls the Earth up (gravitational); the table pushes the book up and the book pushes the table down (contact).

The equality of weight and normal force here is equilibrium, not the third law, and it breaks the moment the book accelerates vertically.

NEWTON'S LAWS AND THE RESULTANT FORCE

SPOT THE ERROR

Nothing pushes a projectile along. Horizontally there is no force, so velocity stays constant; the only force is gravity, straight down. Motion needs no force to continue, only to change.

PROJECTILE MOTION

DEFINITION

The amount of matter in an object: a scalar, measured in kilograms, unchanged by location.

MASS AND WEIGHT

SPOT THE ERROR

Weight and the normal force act on the same body, so they cannot be a third-law pair. The true partner of your weight is your gravitational pull on the Earth; third-law pairs always live on different bodies.

NEWTON'S LAWS AND THE RESULTANT FORCE

DEFINITION

Define: Weight.

MASS AND WEIGHT

EQUATION — NOT ON THE DATA SHEET

Weight from mass:

**W = ?**

MASS AND WEIGHT

CHECK YOURSELF

An astronaut has a mass of 70 kg. On the Moon, $g = 1.62\ \text{N kg}^{-1}$. What are the astronaut's mass and weight on the Moon?

Hint: One of the two quantities never changes.

MASS AND WEIGHT

SPOT THE ERROR

Say what is wrong with this claim:

Mass and weight are two words for the same thing.

MASS AND WEIGHT

DEFINITION

Define: Drag.

DRAG AND TERMINAL SPEED

DEFINITION

Define: Terminal speed.

DRAG AND TERMINAL SPEED

CHECK YOURSELF

A skydiver falls at a terminal speed of $55\ \text{m s}^{-1}$, then opens a parachute and reaches a new terminal speed of $6\ \text{m s}^{-1}$. Explain, in terms of forces, why the new terminal speed is lower.

Hint: The weight has not changed. What has, and what does that do to the speed at which drag can match it?

DRAG AND TERMINAL SPEED

SPOT THE ERROR

Say what is wrong with this claim:

Falling objects just keep speeding up.

DRAG AND TERMINAL SPEED

EQUATION — NOT ON THE DATA SHEET

**$W = mg$**

MASS AND WEIGHT

DEFINITION

The gravitational force acting on an object's mass: $W = mg$, a vector, measured in newtons.

MASS AND WEIGHT

SPOT THE ERROR

Mass is the amount of matter, in kilograms, the same everywhere. Weight is the gravitational force on that mass, in newtons, and it changes with g: on the Moon your mass is untouched and your weight is a sixth.

MASS AND WEIGHT

CHECK YOURSELF

Mass: 70 kg, exactly as on Earth. Mass is the amount of matter and travels with the astronaut.

Weight: $W = mg = 70 \times 1.62 = 113$ N, about a sixth of the 687 N weight on Earth, because the Moon's field strength is about a sixth of the Earth's.

MASS AND WEIGHT

DEFINITION

The constant speed reached when the resistive forces on a falling object have grown to equal its weight, so the resultant force and acceleration are zero.

DRAG AND TERMINAL SPEED

DEFINITION

The resistive force on an object moving through a fluid, acting opposite to the motion and growing with speed.

DRAG AND TERMINAL SPEED

SPOT THE ERROR

Drag grows with speed, so a falling object cannot speed up forever: eventually drag equals weight, the resultant force is zero, and the object continues at that terminal speed.

DRAG AND TERMINAL SPEED

CHECK YOURSELF

Opening the parachute greatly increases the area pushing through the air, so at any given speed the drag is far larger than before.

Drag therefore matches the unchanged weight at a much lower speed, and it is at that lower speed that the resultant returns to zero and the fall becomes steady.

Between the two plateaus, drag exceeds weight, the resultant acts upward, and the skydiver decelerates: the steep falling section of the velocity-time graph.

DRAG AND TERMINAL SPEED

DEFINITION

Define: Momentum.

MOMENTUM AND IMPULSE

DEFINITION

Define: Impulse.

MOMENTUM AND IMPULSE

DEFINITION

Define: Elastic collision.

MOMENTUM AND IMPULSE

EQUATION — NOT ON THE DATA SHEET

Momentum:

**p = ?**

MOMENTUM AND IMPULSE

CHECK YOURSELF

A 2.0 kg trolley moving at 3.0 m $s^{-1}$ collides with a stationary 1.0 kg trolley and they couple together. (a) Find their shared speed. (b) Is the collision elastic?

Hint: Momentum settles part (a). Part (b) is a kinetic-energy audit.

MOMENTUM AND IMPULSE

SPOT THE ERROR

Say what is wrong with this claim:

When something stops, its momentum simply vanishes.

MOMENTUM AND IMPULSE

DEFINITION

Define: Work.

WORK, ENERGY AND POWER

DEFINITION

Define: Power.

WORK, ENERGY AND POWER

DEFINITION

The product of a force and the time for which it acts, $F\Delta t$, equal to the change in momentum it produces.

MOMENTUM AND IMPULSE

DEFINITION

The product of an object's mass and its velocity: $p = mv$, a vector.

MOMENTUM AND IMPULSE

EQUATION — NOT ON THE DATA SHEET

$$p = mv$$

MOMENTUM AND IMPULSE

DEFINITION

A collision in which kinetic energy is conserved as well as momentum.

MOMENTUM AND IMPULSE

SPOT THE ERROR

Momentum never simply vanishes; it is transferred. When a car stops, its momentum passes to the Earth through friction and the road. Only an external force can change a system's total momentum.

MOMENTUM AND IMPULSE

CHECK YOURSELF

(a) Momentum before: $2.0 \times 3.0 = 6.0$ kg m $s^{-1}$. After, the same 6.0 is carried by 3.0 kg, so $v = 6.0 / 3.0 = 2.0$ m $s^{-1}$.

(b) Kinetic energy before: $\frac{1}{2} \times 2.0 \times 3.0^2 = 9.0$ J. After: $\frac{1}{2} \times 3.0 \times 2.0^2 = 6.0$ J. Kinetic energy fell by 3.0 J, so the collision is inelastic, as coupling collisions always are; the 3.0 J became internal energy and sound.

MOMENTUM AND IMPULSE

DEFINITION

The rate of doing work, equivalently the rate of energy transfer: $P = \Delta W/\Delta t$.

WORK, ENERGY AND POWER

DEFINITION

Energy transferred by a force: the force multiplied by the distance moved in the direction of the force, $W = Fs \cos \theta$.

WORK, ENERGY AND POWER

CHECK YOURSELF

A car of mass 1200 kg travels at a constant 30 m $s^{-1}$ against total resistive forces of 600 N. What power does the engine deliver, and why does the mass not matter?

Hint: Constant speed is a statement about the resultant force.

WORK, ENERGY AND POWER

SPOT THE ERROR

Say what is wrong with this claim:

Work means effort.

WORK, ENERGY AND POWER

DEFINITION

Define: Principle of conservation of energy.

CONSERVATION OF ENERGY

CHECK YOURSELF

A child of mass 30 kg starts from rest at the top of a slide 2.5 m high and reaches the bottom at 5.0 m $s^{-1}$. How much energy was transferred to the surroundings by friction? Take g = 9.8 m $s^{-2}$.

Hint: Write the budget: potential in, kinetic out, friction takes the difference.

CONSERVATION OF ENERGY

SPOT THE ERROR

Say what is wrong with this claim:

Energy gets used up.

CONSERVATION OF ENERGY

SPOT THE ERROR

Holding a heavy bag feels like effort but does no work: work needs a force to move something through a distance along the force's line. No displacement, no work, whatever your muscles say.

WORK, ENERGY AND POWER

CHECK YOURSELF

Constant speed means zero acceleration, so the resultant force is zero and the driving force equals the resistive force: 600 N.

$P = Fv = 600 \times 30 = 18$ kW.

The mass is irrelevant because nothing accelerates: mass could only enter through $F = ma$, and $a = 0$. It is a distractor, and a deliberate one.

WORK, ENERGY AND POWER

CHECK YOURSELF

Potential energy given up: $\Delta E_p = mg\Delta h = 30 \times 9.8 \times 2.5 = 735$ J.

Kinetic energy gained: $E_k = 1/2mv^2 = ½ \times 30 \times 5.0^2 = 375$ J.

The books must balance, so friction took 735 - 375 = 360 J, now internal energy in the slide, the child and the air.

CONSERVATION OF ENERGY

DEFINITION

Energy cannot be created or destroyed, only transferred from one form to another; the total energy of an isolated system is constant.

CONSERVATION OF ENERGY

SPOT THE ERROR

Energy is never used up; it is transferred, usually ending as internal energy spread into the surroundings. Dissipated energy is not destroyed — just no longer usefully collected.

CONSERVATION OF ENERGY