

The calculus is what distinguishes this course, and most lost points are a place where an integral or a derivative was replaced by a constant-acceleration formula. Everything below is a rule the readers apply.

How the readers score a physics free response

✗ Choosing an option and then explaining the other one.

✓ **Make the selection first, and make every sentence support it.**

The guidelines state that reasoning cannot earn credit if the incorrect selection is made – the choice gates the explanation.

SG 3 years

✗ Writing an explanation and leaving the choice blank.

✓ **Answer the question explicitly, then justify.**

The guidelines award no credit for an answer without an explanation, and none for an explanation without the answer.

SG 2 years

✗ Ranking quantities without giving the ranking.

✓ **Write the ranking out, then explain it.**

The guidelines state a ranking must be given for any of the explanation points to be earned.

SG2023

✗ Deriving an expression in part (b) using symbols the diagram never defined.

✓ **Define every variable in the diagram or the procedure of part (a).**

The guidelines require all terms to be indicated in part (a) for full credit in part (b).

SG 2 years

✗ Writing kx where the question defined the compression as d .

✓ **Use the question's own symbols.**

The guidelines state that an answer of kx does not earn the point where the quantity was named d .

SG2023

✗ Checking a derived expression only by re-reading the algebra.

✓ **Test a limiting case: does it reduce to g when the mass is zero, or to zero when the angle is?**

The guidelines award credit for a limiting-case argument, and it catches sign and factor errors nothing else will.

MS

✗ Drawing a graph as a horizontal line along the time axis.

✓ **Read what the physics requires before drawing – a flat line at zero is almost never the answer.**

The guidelines state that no credit is earned for a horizontal line along the t -axis.

SG2023

✗ Drawing a free-body diagram with forces starting from anywhere.

✓ **Draw each force from the point where it acts, in the right direction – the normal force from the contact point, perpendicular to the surface.**

Mark schemes specify the origin and direction of each arrow, so a correctly named force in the wrong place earns nothing.

MS

■ Answer in the order asked. Where a part says JUSTIFY, the justification sentence IS the point; where it says CALCULATE, the substituted equation is.

“ ” “ ”

SG 3 years

1 • Kinematics

✗ Using the constant-acceleration equations where the acceleration is a function of time or position.

✓ **Integrate, or separate the variables – $a = v dv/dx$ when a depends on position.**

This is the difference between the calculus-based course and the algebra-based one, and the equations carry a condition.

CED 1.3

✗ Integrating without an initial condition.

✓ **Every integration brings a constant; fix it from the stated initial value.**

The constant is a scored step, and the answer is wrong without it.

CED 1.4

2 • Force and Translational Dynamics

✗ Solving a resistive-force problem with algebra.

✓ **Set up the differential equation from Newton's second law and separate the variables.**

A velocity-dependent force makes the acceleration non-constant by definition.

CED 2.9

✗ Assuming terminal velocity means the acceleration is constant.

✓ **It means the acceleration has become ZERO, because the forces balance.**

The condition is what lets you solve for the speed.

CED 2.9

3 · Work, Energy, and Power

✗ Using $W = Fd$ for a varying force.

✓ $W = \int F dx$ – **the area under the force-displacement graph.**

The constant-force formula is a special case, and the question makes clear when it does not apply.

CED 3.2

✗ Deriving a force from a potential energy function with the wrong sign.

✓ $F = -\frac{dU}{dx}$ – **the minus sign is part of the physics.**

The sign decides whether an equilibrium is stable, which is usually the next part of the question.

CED 3.6

4 · Linear Momentum

✗ Applying momentum conservation where an external impulse acts.

✓ **Check the system and the time interval first – over a short collision, external forces are often negligible.**

Stating why the external forces can be ignored is itself a scored step.

CED 4.2

✗ Computing an impulse from the peak force.

✓ **Impulse is the AREA under the force-time graph, or $\int F dt$.**

The peak is one point on the curve; the area is the change in momentum.

CED 4.1

5 · Torque and Rotational Dynamics

✗ Using the same moment of inertia for every axis.

✓ **Use the parallel-axis theorem when the axis is not through the centre of mass.**

The theorem is examinable content and the shift is often the whole question.

CED 5.4

✗ Integrating for a moment of inertia without expressing dm in terms of the geometry.

✓ **Write $dm = \lambda dx$ or σdA before integrating.**

The substitution is where the marks are; the integral itself is routine.

dm

CED 5.4

6 · Energy and Momentum of Rotating Systems

✗ Conserving angular momentum about a point where an external torque acts.

✓ **Choose the axis so the external torques vanish, and say why you chose it.**

The choice of axis is a scored decision in these questions.

CED 6.3

✗ Forgetting the rotational term in an energy equation for a rolling body.

✓ **Include both:** $\frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$, **linked by** $v = \omega r$.

Omitting it changes the answer by a fixed fraction that looks plausible.

CED 6.1

7 · Oscillations

✗ Asserting that a system is in simple harmonic motion.

✓ **Show it: derive the equation of motion and identify** $d^2x/dt^2 = -\omega^2x$.

The derivation is the scored part; the period follows from ω once it is identified.

SHM

CED 7.1

■ Where a derivation is asked for in terms of given symbols, do not substitute numbers. An expression in the question's own variables is the answer.

SG 2 years

2 · Force and Translational Dynamics

✗ Treating the normal force as always equal to the weight.

✓ **On a slope it is $mg \cos \theta$, and in an accelerating frame it changes with the acceleration.**

The equality holds only on a level surface with no vertical acceleration.

CED 2.5

✗ Drawing the centripetal force as an extra arrow on a free-body diagram.

✓ **It IS the resultant of the forces already there – tension, friction, gravity.**

Adding it double-counts a force that is already on the diagram.

CED 2.8

3 · Work, Energy, and Power

✗ Saying energy is lost in an inelastic collision and stopping.

✓ **Say where it went: internal energy, sound, deformation.**

The transfer is the explanation point; energy is never destroyed.

CED 3.5

7 · Oscillations

✗ Saying the period of a pendulum depends on its mass.

✓ **For small amplitudes it depends on the length and g only.**

The independence follows from the derivation and is a standard discriminator.

CED 7.4

✗ Applying the simple-pendulum formula at a large angle.

✓ **The small-angle approximation $\sin \theta \approx \theta$ is what makes the motion simple harmonic.**

The approximation is an assumption, and questions test whether you know it.

CED 7.4

✗ Answering an oscillation question with the frequency where the period was asked for.

✓ **Check which is wanted: $T = 1/f = 2\pi/\omega$.**

Both come out of the same derivation, so the wrong one is easy to write and earns nothing.

CED 7.2

✗ Treating a spring's potential energy as mgh .

✓ **Elastic potential energy is $\frac{1}{2}kx^2$, measured from the natural length.**

Mixing the two stores is the commonest error in a combined energy problem.

$$\frac{1}{2}kx^2$$

CED 3.4