

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.
本课程的关键是微积分，失分多因用匀变速公式代替积分或求导。

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.
选错了，理由也不给分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.
选项和理由都要写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.
排序题先写出排序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).
变量要在图或步骤中定义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 .
用题目给定的符号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.
用极限情形检验结果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.

不要画成横轴上的直线

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.
受力箭头的起点和方向都要对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.
“说明理由”与“计算”要求不同SG 3 years

1 · Kinematics 运动学

- ✗ 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.
变加速要用微积分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.
积分要用初始条件定常数CED 1.4

2 · Force and Translational Dynamics 力与平动动力学

- ✗ 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.
阻力问题要列微分方程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.
终速时加速度为零CED 2.9

3 · Work, Energy, and Power 功、能与功率

- ✗ 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.
变力做功要积分 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.
力等于势能的负梯度 CED 3.6

4 · Linear Momentum 线动量

- ✗ 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.
要说明外力可忽略 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.
冲量是力-时间曲线下的面积 CED 4.1

5 · Torque and Rotational Dynamics 力矩与转动动力学

- ✗ 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.
轴不过质心要用平行轴定理 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.
先把 dm 用几何量表示 CED 5.4

6 · Energy and Momentum of Rotating Systems 转动系统的能量与动量

- ✗ 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.
选择合适的转轴 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.
滚动要算两部分动能 CED 6.1

7 · Oscillations 振动

- ✗ 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.
要推导出 SHM 方程 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.
符号推导不要代入数字 SG 2 years

2 · Force and Translational Dynamics 力与平动动力学

- ✗ 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.
支持力不总等于重力 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.
向心力不是额外的力 CED 2.8

3 · Work, Energy, and Power 功、能与功率

- ✗ 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.
能量转化为内能等形式 CED 3.5

7 · Oscillations 振动

✗ 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.

单摆周期与质量无关

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.

小角近似才是简谐运动

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.

分清周期与频率

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.

弹性势能是 $\frac{1}{2}kx^2$

CED 3.4