

AP Physics 1 – Practice Set

AP Physics 1 (College Board) · Total marks: 45 · Answers on the last page

This practice set covers kinematics, dynamics, energy, momentum, rotation and simple harmonic motion in AP Physics 1 style, mixing calculation and free-response explanation questions. A calculator is allowed; take $g = 9.81 \text{ m s}^{-2}$.

Section A – Kinematics and Dynamics

1. A ball is launched horizontally with a speed of 15 m s^{-1} from the top of a cliff of height 20 m.
 - (a) Calculate the time taken for the ball to reach the ground.
 - (b) Calculate the horizontal distance travelled by the ball before landing. [4]
2. A block of mass 5 kg rests on a frictionless incline at 30° to the horizontal.
 - (a) Calculate the block's acceleration down the incline.
 - (b) Calculate the normal force on the block. [4]
3. A 10 kg object experiences two perpendicular forces: 30 N directed east and 40 N directed north.
 - (a) Calculate the magnitude of the net force.
 - (b) Calculate the magnitude of the object's acceleration.
 - (c) Calculate the angle of the net force measured from east. [4]
4. A student pushes a box across the floor at constant velocity, then stops pushing and the box decelerates to rest.
Using Newton's first and second laws, explain why the box decelerates once the student stops pushing, and explain what this tells you about the friction force compared with the push force during the constant-velocity phase. [3]

Section B – Energy and Momentum

5. A spring with spring constant $k = 200 \text{ N m}^{-1}$ is compressed by 0.15 m and used to launch a block of mass 2 kg on a frictionless horizontal surface.
 - (a) Calculate the elastic potential energy stored in the spring.
 - (b) Calculate the speed of the block as it leaves the spring. [4]
6. A 3 kg cart moving at 4 m s^{-1} collides head-on with a 2 kg cart moving at 2 m s^{-1} in the opposite direction. The carts stick together after the collision.
Calculate the common velocity of the carts immediately after the collision, stating its direction. [3]
7. A 4 kg box, initially at rest, is pushed with a constant horizontal force of 20 N across a rough floor (coefficient of kinetic friction $\mu = 0.2$) through a distance of 5 m.
 - (a) Calculate the friction force on the box.
 - (b) Calculate the net work done on the box.
 - (c) Calculate the final speed of the box using the work–energy theorem. [5]
8. Explain why total momentum is conserved in a collision between two carts on a track, even though kinetic energy may not be conserved. Refer to Newton's third law in your explanation. [3]

Section C – Rotation and Simple Harmonic Motion (Extended response)

9. A uniform disk of mass 4 kg and radius 0.25 m (moment of inertia $I = \frac{1}{2}MR^2$) starts at rest and a constant torque of 6 N m is applied about its central axis.
- (a) Calculate the moment of inertia of the disk.
 - (b) Calculate the angular acceleration of the disk. [4]
10. A figure skater spinning with moment of inertia 4 kg m² at an angular velocity of 2 rad s⁻¹ pulls in her arms, reducing her moment of inertia to 1 kg m².
- (a) Calculate her new angular velocity, assuming no external torque acts on her.
 - (b) State and explain what happens to her rotational kinetic energy as she pulls her arms in. [4]
11. A 0.5 kg block is attached to a spring of spring constant 50 N m⁻¹ and undergoes simple harmonic motion on a frictionless horizontal surface with amplitude 0.10 m.
- (a) Calculate the period of oscillation.
 - (b) Calculate the maximum speed of the block. [4]
12. A simple pendulum and a mass–spring system both oscillate with simple harmonic motion. Explain why the period of a simple pendulum does not depend on its mass, while the period of a mass–spring system does not depend on the amplitude of oscillation. Support your explanation with reference to the relevant period equations. [3]

Answers

Check your working against these. If an answer does not match, try the question again before looking for the method.

- $h = \frac{1}{2}gt^2 \Rightarrow t = \sqrt{2h/g} = \sqrt{2(20)/9.81} \approx 2.02 \text{ s}$
 - $x = v_0t = 15 \times 2.02 \approx 30.3 \text{ m}$
- $a = g \sin 30^\circ = 9.81 \times 0.5 \approx 4.90 \text{ m s}^{-2}$
 - $N = mg \cos 30^\circ = 5 \times 9.81 \times 0.866 \approx 42.5 \text{ N}$
- $F_{\text{net}} = \sqrt{30^2 + 40^2} = 50 \text{ N}$
 - $a = F_{\text{net}}/m = 50/10 = 5.0 \text{ m s}^{-2}$
 - $\theta = \tan^{-1}(40/30) \approx 53.1^\circ$ north of east
- While being pushed at constant velocity the net force is zero, so the push force must equal the friction force in magnitude (Newton's first law). Once the push force is removed, friction is now the only horizontal force, so by Newton's second law the box has a net force (and acceleration) opposing its motion, causing it to decelerate to rest.
- $E_p = \frac{1}{2}kx^2 = \frac{1}{2}(200)(0.15)^2 = 2.25 \text{ J}$
 - By conservation of energy, $\frac{1}{2}mv^2 = 2.25 \Rightarrow v = \sqrt{2(2.25)/2} = 1.5 \text{ m s}^{-1}$
- Taking the 3 kg cart's direction as positive: $v_f = \frac{m_1u_1 + m_2u_2}{m_1 + m_2} = \frac{(3)(4) + (2)(-2)}{5} = 1.6 \text{ m s}^{-1}$, in the direction of the 3 kg cart's original motion.
- $f = \mu mg = 0.2 \times 4 \times 9.81 \approx 7.85 \text{ N}$
 - $W_{\text{net}} = (F - f)d = (20 - 7.85)(5) \approx 60.8 \text{ J}$
 - $\frac{1}{2}mv^2 = W_{\text{net}} \Rightarrow v = \sqrt{2(60.8)/4} \approx 5.51 \text{ m s}^{-1}$
- During the collision the carts exert equal and opposite forces on each other (Newton's third law) for the same time interval, so they experience equal and opposite impulses. Since the external horizontal forces on the system are negligible, the total momentum of the two-cart system is unchanged, even though some kinetic energy may be converted to heat, sound or deformation.
- $I = \frac{1}{2}(4)(0.25)^2 = 0.125 \text{ kg m}^2$
 - $\alpha = \tau/I = 6/0.125 = 48 \text{ rad s}^{-2}$
- Conservation of angular momentum: $I_1\omega_1 = I_2\omega_2 \Rightarrow \omega_2 = \frac{(4)(2)}{1} = 8 \text{ rad s}^{-1}$
 - Rotational kinetic energy increases (from $\frac{1}{2}(4)(2)^2 = 8 \text{ J}$ to $\frac{1}{2}(1)(8)^2 = 32 \text{ J}$) because the skater does positive work pulling her arms inward against the centripetal requirement, converting internal (muscular) energy into rotational kinetic energy; angular momentum, not kinetic energy, is what is conserved.
- $T = 2\pi\sqrt{m/k} = 2\pi\sqrt{0.5/50} \approx 0.628 \text{ s}$
 - $\omega = \sqrt{k/m} = \sqrt{100} = 10 \text{ rad s}^{-1}$, so $v_{\text{max}} = A\omega = 0.10 \times 10 = 1.0 \text{ m s}^{-1}$
- For a simple pendulum, $T = 2\pi\sqrt{L/g}$: the restoring force ($mg \sin \theta$) and the inertia (ma) both depend on mass in the same way, so mass cancels out and does not appear in the period equation. For a mass-spring system, $T = 2\pi\sqrt{m/k}$: amplitude does not appear because both the restoring force ($-kx$) and the resulting acceleration scale linearly with displacement, so a larger amplitude produces a proportionally larger restoring force and acceleration, keeping the time for one cycle unchanged.

Need this topic taught, not just practised? Book a trial lesson at 50% off with Mr. Ahmad — online worldwide or in person in Dubai.

WhatsApp **+971 55 373 5695** · mathandsciencetutor.com