CSCA Physics · Sample Paper

48 questions · 60 minutes · single choice, exactly one correct option · answer key and worked solutions at the end

1. On $2025\text{–}4\text{–}24$, the Long March 2F Yao–20 carrier rocket carrying the Shenzhou–20 crewed spacecraft was successfully launched at the Jiuquan Satellite Launch Center in Gansu. Suppose that during the initial $1\,\mathrm{s}$, the average thrust of the fuel on the rocket is approximately $6 \times 10^6\,\mathrm{N}$. The mass of the rocket is approximately 500 tons, and is considered essentially unchanged within $1\,\mathrm{s}$. Then the magnitude of the rocket's acceleration during the initial $1\,\mathrm{s}$ is approximately (Take the gravitational acceleration $g = 10\,\mathrm{m/s^2}$)

- **A.** $2\,\mathrm{m/s^2}$
- **B.** $4\,\mathrm{m/s^2}$
- **C.** $6\,\mathrm{m/s^2}$
- **D.** $12\,\mathrm{m/s^2}$

2. A book is placed on a horizontal table in a high–speed train car. The coefficient of kinetic friction between the book and the table is 0.4. The maximum static friction equals the kinetic friction. Take gravitational acceleration $g = 10\,\mathrm{m/s^2}$. If the book does not slide relative to the table, then the maximum acceleration of the high–speed train should not exceed

- **A.** $2.0\,\mathrm{m/s^2}$
- **B.** $4.0\,\mathrm{m/s^2}$
- **C.** $6.0\,\mathrm{m/s^2}$
- **D.** $8.0\,\mathrm{m/s^2}$

3. One end of a light spring is fixed. When a force of magnitude F_1 compresses the other end, the length at equilibrium is l_1. When a force of magnitude F_2 pulls the spring, the length at equilibrium is l_2. The spring's extension and compression remain within the elastic limit. The spring constant is

- **A.** $\dfrac{F_2 - F_1}{l_2 - l_1}$
- **B.** $\dfrac{F_2 + F_1}{l_2 + l_1}$
- **C.** $\dfrac{F_2 + F_1}{l_2 - l_1}$
- **D.** $\dfrac{F_2 - F_1}{l_2 + l_1}$

4. A student observes a train entering the station. The train decelerates from an initial speed of $36\,\mathrm{km/h}$ to a stop. The train's motion can be regarded as uniform deceleration. During the deceleration process, the student's pulse beat 70 times. Given that the student's pulse rate is 60 beats per minute, the distance traveled by the train is approximately

- **A.** $216\,\mathrm{m}$
- **B.** $350\,\mathrm{m}$
- **C.** $600\,\mathrm{m}$
- **D.** $700\,\mathrm{m}$

5. A car travels at a constant speed of $20\,\mathrm{m/s}$ on a straight road. Suddenly, the driver encounters a hazard ahead and applies emergency brakes. The car undergoes uniform deceleration with magnitude of acceleration $8\,\mathrm{m/s^2}$. The distance traveled by the car from the start of braking until it stops is

- **A.** $10\,\mathrm{m}$
- **B.** $20\,\mathrm{m}$
- **C.** $25\,\mathrm{m}$
- **D.** $50\,\mathrm{m}$

6. Let the mass of the sun be M, the period of a planet's revolution around the sun be T, and the orbit is considered to be a circle with radius r. Given that the gravitational constant is G, the above physical quantities describing the planet's motion satisfy

- **A.** $GM = \frac{4\pi^2 r^3}{T^2}$
- **B.** $GM = \frac{4\pi^2 r^2}{T^2}$
- **C.** $GM = \frac{4\pi^2 r^2}{T^3}$
- **D.** $GM = \frac{4\pi r^3}{T^2}$

7. In 2008, Chinese astronomers using the 2.16–meter telescope at the Xinglong Observatory discovered an exoplanet HD173416b orbiting the star HD173416. In 2019, the star and planet were respectively named 'Xihe' and 'Wangshui' by the International Astronomical Union. Astronomical observations show that the mass of the star Xihe is 2 times the mass of the sun. If the orbital motions of Wangshui and Earth are both regarded as uniform circular motion with equal orbital radii, then the ratio of the orbital velocities of Wangshui to Earth is

- **A.** $2\sqrt{2}$
- **B.** 2
- **C.** $\sqrt{2}$
- **D.** $\frac{\sqrt{2}}{2}$

8. Han Xiaopeng was China's first athlete to win a medal in a snow event at the Winter Olympics. During a freestyle skiing aerial trick competition, he descended a certain distance along the 'acceleration zone' maintaining the same posture. Gravity did work of $1900\,\mathrm{J}$ on him, and he did work against resistance of $100\,\mathrm{J}$. During this process, Han Xiaopeng's

- **A.** kinetic energy increased by $1900\,\mathrm{J}$
- **B.** kinetic energy increased by $2000\,\mathrm{J}$
- **C.** gravitational potential energy decreased by $1900\,\mathrm{J}$
- **D.** gravitational potential energy decreased by $2000\,\mathrm{J}$

9. The Lushan waterfall, with the verse "torrents plunge three thousand feet, as if the Milky Way falling from the sky", has a height of $150\mathrm{m}$ and water flow rate of $10\mathrm{m}^3/\mathrm{s}$. Assuming power generation using the waterfall with energy conversion efficiency of 70%, the generated power is

- **A.** 10^9
- **B.** 10^7
- **C.** 10^5
- **D.** 10^3

10. When there is no wind, a raindrop experiences air resistance and falls at a constant speed vertically to the ground near the surface. For a raindrop of mass m falling at speed v through a height h near the ground, the work done against air resistance is (where the gravitational acceleration is g)

A. 0

B. mgh

C. $\frac{1}{2}mv^2 - mgh$

D. $\frac{1}{2}mv^2 + mgh$

11. Below a thunderstorm cloud, the electric field strength in the vertical direction is $10^4\,\mathrm{V/m}$. A raindrop with radius $1\,\mathrm{mm}$ does not fall in this electric field. (Take $g = 10\,\mathrm{m/s^2}$ and the density of water is $10^3\,\mathrm{kg/m^3}$.) The minimum magnitude of electric charge carried by the raindrop is approximately

A. $2 \times 10^{-9}\,\mathrm{C}$

B. $4 \times 10^{-9}\,\mathrm{C}$

C. $6 \times 10^{-9}\,\mathrm{C}$

D. $8 \times 10^{-9}\,\mathrm{C}$

12. During the War of Resistance against Japan, our troops seized many enemy weapons to arm themselves, including a certain light machine gun with bullet head mass approximately $8\,\mathrm{g}$ and muzzle velocity approximately $750\,\mathrm{m/s}$. A soldier using this machine gun for continuous firing over 1 minute experiences an average recoil force on the gun of approximately $12\,\mathrm{N}$. The number of bullets fired in this 1 minute is approximately

A. 40

B. 80

C. 120

D. 160

13. $4\,(\mathrm{T})$ times $2\,(\mathrm{A})$ times $3\,(\mathrm{m})$ is

A. $24\,\mathrm{W}$

B. $24\,\mathrm{J}$

C. $24\,\mathrm{V}$

D. $24\,\mathrm{N}$

14. Let a rock P_1 with mass $1\,\mathrm{kg}$ fall freely from a great height. The velocity of P_1 at the end of the first $1\,\mathrm{s}$ of falling is v_1. Then bind P_1 and a rock with mass $2\,\mathrm{kg}$ into a single system P_2, and let P_2 fall freely from the original height. The velocity of P_2 at the end of the first $1\,\mathrm{s}$ of falling is v_2. Taking $g = 10\,\mathrm{m/s^2}$, then

A. $v_1 = 5\,\mathrm{m/s}$

B. $v_1 = 10\,\mathrm{m/s}$

C. $v_2 = 15\,\mathrm{m/s}$

D. $v_2 = 30\,\mathrm{m/s}$

15. Ampere discovered the law governing the interaction force between currents through experimental research. If two segments of parallel straight wires, with lengths Δl_1 and Δl_2 respectively, carrying currents I_1 and I_2 respectively, are separated by a distance r, the magnitude of the interaction force can be expressed as $\Delta F = k\frac{I_1 I_2 \Delta l_1 \Delta l_2}{r^2}$. The unit of the proportionality coefficient k is

A. $\mathrm{kg \cdot m/(s^2 \cdot A)}$
B. $\mathrm{kg \cdot m/(s^2 \cdot A^2)}$
C. $\mathrm{kg \cdot m^2/(s^3 \cdot A)}$
D. $\mathrm{kg \cdot m^2/(s^3 \cdot A^3)}$

16. A transverse wave has a wavelength of $1.4\,\mathrm{m}$. At a certain point in the propagation direction, the shortest time to return from maximum displacement to the equilibrium position is $0.14\,\mathrm{s}$. The wave speed is

A. $0.4\,\mathrm{m/s}$
B. $2.5\,\mathrm{m/s}$
C. $5\,\mathrm{m/s}$
D. $10\,\mathrm{m/s}$

17. A weather balloon of mass M descends uniformly. The buoyant force F on the balloon remains constant. During motion, the drag force depends only on the speed, and the gravitational acceleration is g. To make the balloon rise uniformly at the same speed, the mass that must be reduced from the balloon's basket is

A. $2\left(M - \frac{F}{g}\right)$
B. $M - \frac{2F}{g}$
C. $2M - \frac{F}{g}$
D. g

18. Two ends of a light elastic rope are fixed on a horizontal ceiling at two points $80\ \mathrm{cm}$ apart. The natural length of the elastic rope is also $80\ \mathrm{cm}$. A hook with mass is hung at the midpoint of the rope, and at equilibrium the total length of the rope becomes $100\ \mathrm{cm}$. If the two ends of the rope are slowly moved to the same point on the ceiling, then the total length of the rope becomes (the elastic rope always remains within its elastic limit)

A. $86\ \mathrm{cm}$
B. $92\ \mathrm{cm}$
C. $98\ \mathrm{cm}$
D. $104\ \mathrm{cm}$

19. The cross-sectional area of a musical fountain nozzle is $2 \times 10^{-4}\,\mathrm{m}^2$. The water spray velocity is about $10\,\mathrm{m/s}$. The density of water is $1 \times 10^3\,\mathrm{kg/m^3}$. The power of the fountain nozzle is approximately

A. $10\,\mathrm{W}$
B. $20\,\mathrm{W}$
C. $100\,\mathrm{W}$
D. $200\,\mathrm{W}$

20. An object is pulled up a fixed incline at angle 30° at constant velocity by a light rope. The rope is parallel to the incline. The coefficient of kinetic friction between the object and incline is $\frac{\sqrt{3}}{3}$, and the acceleration due to gravity is taken as $10\ \mathrm{m/s^2}$. If the maximum tension the rope can withstand is $1500\ \mathrm{N}$, then the maximum mass of the object is

A. $150\ \mathrm{kg}$

B. $100\sqrt{3}\ \mathrm{kg}$

C. $200\ \mathrm{kg}$

D. $200\sqrt{3}\ \mathrm{kg}$

21. A dust particle with mass $2 \times 10^{-13}\ \mathrm{kg}$ falls stably vertically at a height of $20\ \mathrm{m}$ above the ground. During its fall, the resistance force is proportional to the velocity v with proportionality coefficient $1 \times 10^{-9}\ \mathrm{kg/s}$. Taking $g = 10\ \mathrm{m/s^2}$, the time for it to fall to the ground is approximately

A. $0.5\ \mathrm{h}$

B. $3\ \mathrm{h}$

C. $28\ \mathrm{h}$

D. $166\ \mathrm{h}$

22. A point charge (charge q, mass m) undergoes projectile motion in a uniform electric field (field strength E), subject to both gravity and electric force. The horizontal displacement is $\dfrac{d}{2}$. Which of the following statements is correct?

A. Acceleration $a = \dfrac{\sqrt{(Eq)^2 + (mg)^2}}{m}$, direction is horizontal

B. Horizontal motion time $t = \sqrt{\dfrac{md}{Eq}}$

C. Vertical displacement $h = \dfrac{1}{2}gt^2 = \dfrac{mgd}{2Eq}$, this statement is incorrect

D. Work done by electric force $W = \dfrac{Eqd}{2}$, this statement is incorrect

23. In scientific research, scientists often compare unknown phenomena with known phenomena to identify common features and further infer the characteristics of unknown phenomena. When studying the attraction between unlike charges, French physicist Coulomb used the relationship between a torsion balance's oscillation period and the distance between charges as an analogy to the relationship between a simple pendulum's oscillation period and the distance from the pendulum bob to Earth's center. Given that the pendulum length is l, the gravitational constant is G, Earth's mass is M, and the distance from the pendulum bob to Earth's center is r, then the relationship between the simple pendulum's oscillation period T and distance r is

A. $T = 2\pi r\sqrt{\frac{GM}{l}}$

B. $T = 2\pi r\sqrt{\frac{l}{GM}}$

C. $T = \frac{2\pi}{r}\sqrt{\frac{GM}{l}}$

D. $T = 2\pi l\sqrt{\frac{r}{GM}}$

24. A tennis player hits the ball twice with the impact point at a horizontal distance L from the net and at heights $\frac{L}{2}$ and L respectively above the ground. The speed of the ball leaving the racket is the same both times, with directions slanting upward and downward respectively, each making an angle θ with the horizontal. After hitting, the ball just barely passes over the net directly both times. The motion plane is perpendicular to the net. Neglecting air resistance, the value of $\tan\theta$ is

A. $\frac{1}{2}$
B. $\frac{1}{3}$
C. $\frac{1}{4}$
D. $\frac{1}{6}$

25. A tourist on the shore of Qiandao Lake wants to board a tour boat. The waves are quite rough that day, and the boat bobs up and down. The bobbing motion of the boat can be simplified as simple harmonic motion in the vertical direction, with amplitude $A = 20\,\mathrm{cm}$ and period $T = 3.0\,\mathrm{s}$. When the boat rises to its highest point, the deck is exactly level with the dock ground. The passenger can comfortably board when the height difference between the ground and deck does not exceed $10\,\mathrm{cm}$. The time within one period during which the passenger can comfortably board is

A. $0.5\,\mathrm{s}$
B. $0.75\,\mathrm{s}$
C. $1.0\,\mathrm{s}$
D. $1.5\,\mathrm{s}$

26. Two train cars have rated powers P_1 and P_2 respectively, and can reach maximum speeds v_1 and v_2 respectively on a certain straight railway track. The resistance experienced by each train car remains unchanged before and after coupling. The maximum speed that can be reached by the coupled train on this track is

A. $\frac{P_1v_1 + P_2v_2}{P_1 + P_2}$
B. $\frac{P_1v_2 + P_2v_1}{P_1 + P_2}$
C. $\frac{(P_1 + P_2)v_1v_2}{P_1v_1 + P_2v_2}$
D. $\frac{(P_1 + P_2)v_1v_2}{P_1v_2 + P_2v_1}$

27. In a collision test, two train heads each with mass $1.2 \times 10^5\,\mathrm{kg}$ start from rest at opposite ends of a straight track of length $6.4\,\mathrm{km}$ and move toward each other with acceleration $0.25\,\mathrm{m/s^2}$. The total kinetic energy of the two train heads just before collision is

A. 0
B. $9.6 \times 10^7\,\mathrm{J}$
C. $1.92 \times 10^8\,\mathrm{J}$
D. $3.84 \times 10^8\,\mathrm{J}$

28. The same power P is transmitted through an ideal transformer over a transmission line with total resistance R. The primary voltage U is kept constant. When the ratio of secondary to primary turns is k, the power loss in the line is P_1. If the turns ratio is increased to nk, the power loss in the line is P_2. Then P_1 and $\frac{P_2}{P_1}$ are, respectively

- **A.** $\frac{PR}{kU}$, $\frac{1}{n}$
- **B.** $\left(\frac{PR}{kU}\right)^2 R$, $\frac{1}{n}$
- **C.** $\frac{PR}{kU}$, $\frac{1}{n^2}$
- **D.** $\left(\frac{P}{kU}\right)^2 R$, $\frac{1}{n^2}$

29. High-altitude falling objects pose serious hazards to pedestrians. If a $50\,\mathrm{g}$ egg falls from the 25th floor of a residential building and the collision time with the ground is approximately $2\,\mathrm{ms}$, the impact force of the egg on the ground is approximately:

- **A.** $10\,\mathrm{N}$
- **B.** $10^2\,\mathrm{N}$
- **C.** $10^3\,\mathrm{N}$
- **D.** $10^4\,\mathrm{N}$

30. In proton therapy, a linear accelerator is used to accelerate protons. The protons are accelerated from rest to $1.0 \times 10^7\,\mathrm{m/s}$. The electric field strength of the accelerating field is $1.3 \times 10^5\,\mathrm{N/C}$. The mass of a proton is $1.67 \times 10^{-27}\,\mathrm{kg}$ and its charge is $1.6 \times 10^{-19}\,\mathrm{C}$. Which of the following statements is correct?

- **A.** The electric potential energy of the proton increases during acceleration
- **B.** The electric force on the proton is approximately $2 \times 10^{-15}\,\mathrm{N}$
- **C.** The time required to accelerate the proton is approximately $8 \times 10^{-6}\,\mathrm{s}$
- **D.** The acceleration distance in the accelerator is approximately $4\,\mathrm{m}$

31. Xiao Ming fills a rubber tube with salt water, sealing both ends with thick copper wires to form a closed salt water column. He connects this salt water column to a power source with constant emf and internal resistance. Holding the salt water column at both ends, he stretches it horizontally at constant speed to 1.2 times its original length. Neglecting the effects of temperature on resistivity, the salt water column

- **A.** has increased current passing through it
- **B.** has increased voltage across its ends
- **C.** has resistance increased by a factor of 1.2 times the original
- **D.** has electrical power increased by a factor of 1.44 times the original

32. On a smooth table surface, a soft conductor of length πL is fixed at both ends, with the distance between the fixed points being $2L$. A current I flows through the conductor, and it is placed in a uniform magnetic field with magnetic induction B pointing vertically downward. The tension in the conductor is

- **A.** BIL
- **B.** $2BIL$
- **C.** πBIL
- **D.** $2\pi BIL$

33. The 'artificial sun' Tokamak device uses a strong magnetic field to confine high–temperature plasma, restricting the charged particles to the device's interior and preventing collision with the device walls. It is known that the average kinetic energy of charged particles in the plasma is proportional to the plasma temperature T. To confine higher–temperature plasma while keeping the particles' orbital radius constant, a stronger magnetic field is needed. From this, the required magnetic flux density B is proportional to

- **A.** $\sqrt{T}$
- **B.** T
- **C.** $\sqrt{T^3}$
- **D.** T^2

34. A person holding a square plane mirror with side length $6\,\mathrm{cm}$ measures the height of a tree behind them. The mirror plane remains perpendicular to the ground, with the mirror at a distance of $0.4\,\mathrm{m}$ from the eyes. At one position, the person can just see the complete image of the tree in the mirror. After walking forward $6.0\,\mathrm{m}$, they find that using only $\frac{5}{6}$ of the mirror's length allows them to see the entire tree image. The height of the tree is approximately

- **A.** $5.5\,\mathrm{m}$
- **B.** $5.0\,\mathrm{m}$
- **C.** $4.5\,\mathrm{m}$
- **D.** $4.0\,\mathrm{m}$

35. Regarding equipotential surfaces of an electrostatic field, which of the following statements is correct?

- **A.** Two equipotential surfaces with different potentials may intersect
- **B.** Electric field lines are everywhere perpendicular to equipotential surfaces
- **C.** The electric field strength at all points on the same equipotential surface must be equal
- **D.** When a negative test charge is moved from an equipotential surface at higher potential to one at lower potential, the electric force does positive work

36. Regarding the history of physics, which of the following statements is correct?

- **A.** Kepler proposed the three laws of planetary motion, stating that all planetary orbits in the solar system are elliptical
- **B.** Cavendish measured the gravitational constant through the Cavendish balance experiment
- **C.** Millikan determined the electric charge of the electron through the oil drop experiment
- **D.** Oersted discovered the magnetic effect of electric current

37. An ideal transformer has a sinusoidal alternating voltage applied to the primary coil with constant maximum value, and the secondary coil is connected to an adjustable resistor R. Let the primary coil current be I_1, input power P_1, secondary coil current I_2, and output power P_2. When R increases,

- **A.** I_1 decreases, P_1 increases
- **B.** I_1 decreases, P_1 decreases
- **C.** I_2 increases, P_2 decreases
- **D.** I_2 increases, P_2 increases

38. Which of the following statements about electromagnetic waves is correct?

A. Electromagnetic waves must propagate through a medium

B. Electromagnetic waves can undergo diffraction

C. Electromagnetic waves do not undergo polarization

D. Electromagnetic waves cannot carry information

39. When the sun, Earth, and moon are collinear with the Earth positioned between the sun and the moon, a total lunar eclipse occurs. At this time, the entire moon appears dark red. Which of the following statements about the cause of the lunar eclipse and the reason the moon appears dark red is correct?

A. A total lunar eclipse occurs when the moon enters the Earth's umbra, and the moon appears dark red because violet light from the sun is refracted by the Earth's atmosphere onto the moon

B. A total lunar eclipse occurs because sunlight is completely blocked by the moon

C. Sunlight that travels in straight lines is completely blocked by the opaque Earth, so the moon cannot be seen from Earth; this is a total lunar eclipse. The entire moon appears dark red because red light from the sun is refracted by the Earth's atmosphere onto the moon

D. A total lunar eclipse is a diffraction phenomenon, and the moon appears dark red because red light has the shortest wavelength

40. In the International System of Units, which of the following is both a fundamental quantity and has a fundamental unit?

A. Mass; kilogram

B. Energy; joule

C. Resistance; ohm

D. Charge; coulomb

41. A certain life-saving ring is mainly sealed with a high-pressure gas canister, and the gas inside the air bag is treated as an ideal gas. As the sealed air bag rises with a person, if the temperature of the gas inside the air bag remains constant and the volume increases, then

A. The external environment does positive work on the gas inside the air bag

B. The pressure of the gas inside the air bag increases

C. The internal energy of the gas inside the air bag increases

D. The gas inside the air bag absorbs heat from the external environment

42. Among the following four groups of physical quantities, which one contains only scalars?

A. Electric potential; Electric field strength

B. Heat; Power

C. Momentum; Kinetic energy

D. Velocity; Acceleration

43. In the 4th century BCE, China's text "Mojing" stated "force is the means by which shaped matter propels or accelerates," meaning force is the cause of sudden propulsion or accelerated motion of objects. The correct way to express the unit of force using basic SI unit symbols is

A. $\mathrm{kg \cdot m \cdot s^{-1}}$

B. $\mathrm{kg \cdot m \cdot s^{-2}}$

C. $\mathrm{Pa \cdot m^2}$

D. $\mathrm{J \cdot m^{-1}}$

44. A bubble slowly rises from the bottom of a constant–temperature water tank. Treat the gas inside the bubble as an ideal gas with constant number of molecules and constant atmospheric pressure. During the rising process, the gas inside the bubble

A. has internal energy that increases

B. has pressure that increases

C. has constant volume

D. absorbs heat from the water

45. A movie can simulate an actor easily jumping up to a high place by playing backward the scene of the actor jumping down from a height. From the audience's perspective, the change in velocity is

A. speed is greater at low positions, acceleration directed downward

B. speed is greater at high positions, acceleration directed upward

C. speed is greater at low positions, acceleration directed upward

D. speed is greater at high positions, acceleration directed downward

46. Using the gravitational constant G and one of the following sets of data, which does NOT allow us to calculate Earth's mass?

A. Earth's radius and the gravitational acceleration near Earth's surface (not considering Earth's rotation)

B. The orbital speed and period of an artificial satellite orbiting Earth near its surface

C. The orbital period of the Moon around Earth and the distance between the Moon and Earth

D. Earth's orbital period around the Sun and the distance between Earth and the Sun

47. Applying physics knowledge to analyze common phenomena in life can make physics learning more interesting and profound. For example, when a hand palm supports an object and moves vertically upward from rest until the object is thrown. Which of the following analyses is correct?

A. During the upward motion of the hand supporting the object, the object is always in a state of overweight

B. During the upward motion of the hand supporting the object, the object is always in a state of weightlessness

C. At the instant the object leaves the hand, the object's acceleration is greater than gravitational acceleration

D. At the instant the object leaves the hand, the hand's acceleration is greater than gravitational acceleration

48. A beam of monochromatic light obliquely strikes one surface of a thick parallel glass plate, undergoes two refractions, and exits from the other surface of the glass plate. The emergent light ray is laterally displaced by a distance relative to the incident light ray. Under which of the following conditions is the lateral displacement maximum?

A. Red light with incident angle of 30°

B. Red light with incident angle of 45°

C. Violet light with incident angle of 30°

D. Violet light with incident angle of 45°

Answer key

1	2	3	4	5	6	7	8
A	B	C	B	C	A	C	C
9	10	11	12	13	14	15	16
B	B	B	C	D	B	B	B
17	18	19	20	21	22	23	24
A	B	C	A	B	B	B	C
25	26	27	28	29	30	31	32
C	D	C	D	C	D	B	A
33	34	35	36	37	38	39	40
A	C	B	A	B	B	C	A
41	42	43	44	45	46	47	48
D	B	B	D	A	D	D	D

Worked solutions

1. A [Detailed solution] According to the problem, by Newton's second law, $F - mg = ma$. Substituting the data gives $a = \dfrac{6\times10^6 - 5\times10^6}{5\times10^5}\ \mathrm{m/s^2} = 2\ \mathrm{m/s^2}$. The answer is A.

2. B The book is placed on a horizontal table. If the book does not slide relative to the table, the maximum static friction provides the acceleration. Thus $f_\mathrm{m} = \mu mg = ma_\mathrm{m}$, solving gives $a_\mathrm{m} = \mu g = 0.4\times10 = 4\,\mathrm{m/s^2}$. Since the book remains stationary relative to the train, the maximum acceleration of the train is $4\,\mathrm{m/s^2}$. Answer: B.

3. C By Hooke's law, $F = kx$, where x is the deformation. Let the original length be l_0. Then $F_1 = k(l_0 - l_1)$ and $F_2 = k(l_2 - l_0)$. Solving the system of equations: $k = \frac{F_2+F_1}{l_2-l_1}$. Thus option C is correct.

4. B The train's motion time is $t = \dfrac{60}{60}\times 70\ \mathrm{s} = 70\ \mathrm{s}$. The distance traveled by the train is $x = \dfrac{v_0}{2}t = \dfrac{10}{2}\times 70\ \mathrm{m} = 350\ \mathrm{m}$. Therefore, the answer is B.

5. C The car undergoes uniform deceleration. Using $v_0^2 = 2ax$, we solve to get $x = \frac{v_0^2}{2a} = \frac{20^2}{2\times8}\ \mathrm{m} = 25\,\mathrm{m}$. Therefore, select C.

6. A Let the planet's mass be m. The gravitational force provides the centripetal force: $F_n = G\frac{Mm}{r^2} = mr\left(\frac{2\pi}{T}\right)^2$. Solving for GM, we obtain $GM = \frac{4\pi^2 r^3}{T^2}$. The answer is A.

7. C Both Earth orbiting the sun and planet Wangshui orbiting the star Xihe undergo uniform circular motion with gravitational force providing the centripetal force, so $G\frac{Mm}{r^2} = m\frac{v^2}{r}$, which gives the orbital linear velocity as $v = \sqrt{\frac{GM}{r}}$. The mass ratio of the central bodies is $2:1$, and the orbital radii are equal. Therefore, the ratio of Wangshui's to Earth's orbital velocity is $\sqrt{2}$. Answer: C.

8. C According to the work–energy theorem, the change in kinetic energy equals the work done by the net force, which is $1900\,\mathrm{J} - 100\,\mathrm{J} = 1800\,\mathrm{J}$. Options A and B are incorrect. The work done by gravity equals the change in gravitational potential energy, so gravitational potential energy decreased by $1900\,\mathrm{J}$. Option C is correct; option D is incorrect. Key concept: the work done by gravity equals the change in gravitational potential energy; the work done by forces other than gravity equals the change in mechanical energy.

9. B The mass of water flowing in time Δt is $m = \rho Q\Delta t = 1.0\times10^3\times10\times\Delta t = 1.0\times10^4\Delta t$ kg. The gravitational potential energy converts to electrical energy. Thus the power is $P = \frac{mgh}{\Delta t}\times 70\% = \frac{1.0\times10^4\times10\times150}{1}\times0.70 = 1.05\times10^7\ \mathrm{W} \approx 1.1\times10^7\ \mathrm{W}$. Answer: B.

10. B Near the ground, the raindrop moves at uniform velocity, so by the work–energy theorem, $mgh - W_{\text{friction}} = 0$, where W_{friction} is the work done by friction. Thus the work done against air resistance is mgh. The answer is B.

11. B A charged raindrop remains stationary under the action of electric force and gravitational force. By equilibrium conditions, electric force and gravitational force are equal in magnitude and opposite in direction: $mg = Eq$, where $m = \rho V$, $V = \frac{4}{3}\pi r^3$. Solving: $q = \frac{mg}{E} = \frac{\rho \cdot \frac{4}{3}\pi r^3 g}{E} = \frac{10^3 \times \frac{4}{3} \times 3.14 \times 10^{-9} \times 10}{10^4}\,\mathrm{C} \approx 4 \times 10^{-9}\,\mathrm{C}$. Thus the answer is B.

12. C Let the number of bullets fired in 1 minute be n. Applying the momentum theorem to the n bullets: $Ft = nmv_0$. Substituting the data: $12 \times 60 = n \times 0.008 \times 750$, solving gives $n = 120$. The answer is C.

13. D T denotes magnetic flux density (units of tesla), A denotes electric current (units of amperes), and m denotes length (units of meters). By the formula $F = BIL$, the product of these three quantities gives force, thus $F = 24\,\mathrm{N}$. Therefore A, B, and C are incorrect, and D is correct. The answer is D.

14. B Heavy objects in free fall undergo free fall motion, which is independent of mass. Therefore, after falling for 1 s, the velocity is $v_1 = v_2 = gt = 10\,\mathrm{m/s^2} \times 1\,\mathrm{s} = 10\,\mathrm{m/s}$. Thus B is correct.

15. B [Detailed solution] Rearranging the formula given in the problem, $\Delta F = k\dfrac{I_1 I_2 \Delta l_1 \Delta l_2}{r^2}$, gives $k = \dfrac{\Delta F r^2}{I_1 I_2 \Delta l_1 \Delta l_2}$. Substituting the corresponding units of the physical quantities, the unit of the proportionality coefficient k is $\dfrac{\mathrm{N}}{\mathrm{A^2}} = \dfrac{\mathrm{kg \cdot m/s^2}}{\mathrm{A^2}} = \mathrm{kg \cdot m/(s^2 \cdot A^2)}$. The answer is B.

16. B The shortest time for a point to return from maximum displacement to the equilibrium position is one quarter of the period, so the period $T = 0.14 \times 4\,\mathrm{s} = 0.56\,\mathrm{s}$. Therefore, the wave speed $v = \frac{\lambda}{T} = \frac{1.4\,\mathrm{m}}{0.56\,\mathrm{s}} = 2.5\,\mathrm{m/s}$.

17. A During uniform descent, the balloon experiences weight Mg (downward), buoyant force F (upward), and drag force f (upward). Force balance: $Mg = F + f$. During uniform ascent, the balloon experiences weight $(M - \Delta m)g$ (downward), buoyant force F (upward), and drag force f (downward, since drag opposes motion and the speed is the same). Force balance: $(M - \Delta m)g + f = F$. Solving these two equations: $\Delta m = 2\left(M - \frac{F}{g}\right)$. Therefore, A is correct.

18. B When the rope length becomes $100\,\mathrm{cm}$, it has extended by $20\,\mathrm{cm}$, from which we can determine the tension in the rope. Using the equilibrium condition of concurrent forces, we can find the spring constant, and then calculate the total length when the two ends are at the same point. Solution: As shown, the rope's natural length is $80\,\mathrm{cm}$ and extends to $100\,\mathrm{cm}$, so the extension is $20\,\mathrm{cm}$. Each segment AB is $50\,\mathrm{cm}$ long, with an extension of $10\,\mathrm{cm} = 0.1\,\mathrm{m}$. Let the spring constant of the rope be k, then the tension is $F = 0.1k$. Decomposing the rope tension into horizontal and vertical components, the vertical component is $F_x = 0.1k \times \cos 53^\circ = 0.06k$. The combined vertical tension of both rope segments is $2F_x$. Since the object is in equilibrium, the combined tension equals weight: $0.12k = mg$, so $k = \frac{mg}{0.12}$. When the two ends move to the same point, the angle between the two rope segments is 0, and each segment extends by x. The combined tension of both segments is $2kx = mg$, solving gives $x = 0.06\,\mathrm{m}$. Therefore the total rope length is $80\,\mathrm{cm} + 2 \times 6\,\mathrm{cm} = 92\,\mathrm{cm}$. The answer is B.

19. C Let the mass of water flowing from the nozzle in time Δt be $m = \rho S v \cdot \Delta t$. The power of the fountain nozzle equals the increase in kinetic energy of the water expelled in time Δt, that is, $P = \dfrac{W}{\Delta t} = \dfrac{\frac{1}{2}mv^2}{\Delta t}$. Solving, we get $P = 100\,\mathrm{W}$. The answer is C.

20. A For equilibrium along the incline: $F = mg\sin 30^\circ + \mu mg\cos 30^\circ$. When tension reaches its maximum value, mass is maximum: $1500 = m \times 10 \times (\frac{1}{2} + \frac{\sqrt{3}}{3} \times \frac{\sqrt{3}}{2}) = m \times 10 \times 1$, so $m = 150\,\mathrm{kg}$. Answer: A.

21. B At small speeds, the resistance force is small. By Newton's second law, $mg - kv = ma$. As speed increases, resistance increases and acceleration decreases. When $a = 0$, the velocity reaches its maximum stable value (terminal velocity): $mg = kv_m$, giving $v_m = \dfrac{mg}{k} = \dfrac{2 \times 10^{-13} \times 10}{1 \times 10^{-9}} = 2 \times 10^{-3}\,\mathrm{m/s}$. Approximating uniform motion throughout, the falling time is $t = \dfrac{h}{v_m} = \dfrac{20}{2 \times 10^{-3}} = 1 \times 10^4\,\mathrm{s} = \dfrac{1 \times 10^4}{3600}\,\mathrm{h} \approx 2.8\,\mathrm{h}$. Therefore, the answer is B.

22. B The point charge is subject to gravity and electric force, so $a = \dfrac{\sqrt{(Eq)^2 + (mg)^2}}{m}$, making option A incorrect. By the independence of motion, if the horizontal motion time is t, then $\dfrac{d}{2} = \dfrac{1}{2} \cdot \dfrac{Eq}{m} t^2$, solving gives $t = \sqrt{\dfrac{md}{Eq}}$, so option B is correct. The vertical displacement is $h = \dfrac{1}{2} g t^2 = \dfrac{mgd}{2Eq}$, making option C incorrect. The work done by electric force is $W = \dfrac{Eqd}{2}$, making option D incorrect.

23. B The gravitational force provides the centripetal acceleration: $G\frac{Mm}{r^2} = mg$. The simple pendulum period formula is $T = 2\pi\sqrt{\frac{l}{g}}$. Combining these gives $g = \frac{GM}{r^2}$, so $T = 2\pi\sqrt{\frac{l}{g}} = 2\pi\sqrt{\frac{lr^2}{GM}} = 2\pi r\sqrt{\frac{l}{GM}}$. Answer: B.

24. C The ball undergoes uniform motion horizontally: $t = \dfrac{L}{v_0 \cos\theta}$. Let the net height be h. For the ball from point A (height L, slanting downward): $L - h = v_0 \sin\theta \cdot t + \dfrac{1}{2} g t^2$. For the ball from point B (height $\dfrac{L}{2}$, slanting upward): $\dfrac{L}{2} - h = -v_0 \sin\theta \cdot t + \dfrac{1}{2} g t^2$. Combining these equations gives $\tan\theta = \dfrac{1}{4}$. Therefore, the answer is C.

25. C [Analysis] Model the boat's bobbing as simple harmonic motion in the vertical direction, write the equation of motion, and use mathematics to solve for the time. [Solution] Model the boat's bobbing as simple harmonic motion in the vertical direction. Starting the clock when the boat rises to its highest point, the equation of motion is: $y = A\cos\frac{2\pi}{T}t$. Substituting gives: $y = 20\cos\frac{2\pi}{3}t\,(\mathrm{cm})$. When $y = 10\,\mathrm{cm}$, solving gives: $\frac{2\pi}{3}t = \frac{\pi}{3}$, thus $t = 0.5\,\mathrm{s}$. Therefore, within one period, the time during which the passenger can comfortably board is $2t = 1.0\,\mathrm{s}$. The answer is C. [Note] The key to solving this problem is to clarify the motion model of the boat, write the equation of simple harmonic motion, and then use mathematics to solve.

26. D From the given information, the two train cars separately have $P_1 = f_1 v_1$ and $P_2 = f_2 v_2$. When coupled, $P_1 + P_2 = (f_1 + f_2)v$. Combining these equations gives $v = \dfrac{(P_1 + P_2)v_1 v_2}{P_1 v_2 + P_2 v_1}$. The answer is D.

27. C Each train head travels $\frac{L}{2} = 3.2 \times 10^3\,\mathrm{m}$. The velocity just before collision satisfies $v^2 = 2a \cdot \frac{L}{2} = 2 \times 0.25 \times 3.2 \times 10^3\,(\mathrm{m/s})^2 = 1.6 \times 10^3\,(\mathrm{m/s})^2$. The total kinetic energy just before collision: $E_k = 2 \times \frac{1}{2}mv^2 = 1.2 \times 10^5 \times 1.6 \times 10^3\,\mathrm{J} = 1.92 \times 10^8\,\mathrm{J}$. Key concepts: kinematics and kinetic energy.

28. D [Analysis] For an ideal transformer, the voltage across the primary and secondary coils is proportional to the number of turns; the transformer does not change the power. Using $P = UI$, find the current in the transmission line, then use the power formula to solve for the power loss in the transmission line. [Solution] When the turns ratio is k, the transmission voltage is kU, the transmitted power is $P = kUI$, so $P_1 = I^2 R = \frac{P^2 R}{k^2 U^2}$. When the turns ratio is nk, the transmission voltage is nkU, the transmitted power is $P = nkUI'$, so $P_2 = I'^2 R = \frac{P^2 R}{n^2 k^2 U^2}$. Thus $\frac{P_2}{P_1} = \frac{1}{n^2}$. Therefore, D is correct.

29. C Assuming each floor height is approximately $3\,\mathrm{m}$, total height $h = (25 - 1) \times 3\,\mathrm{m} = 72\,\mathrm{m}$. Free fall time: $t_1 = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 72}{10}}\,\mathrm{s} \approx 3.8\,\mathrm{s}$. Collision time: $t_2 = 2\,\mathrm{ms} = 0.002\,\mathrm{s}$. By impulse–momentum theorem: $mg(t_1 + t_2) - Ft_2 = 0$, so $F = \frac{mg(t_1 + t_2)}{t_2} = \frac{0.05 \times 10 \times 3.802}{0.002} \approx 950\,\mathrm{N} \approx 10^3\,\mathrm{N}$.

30. D During acceleration, the electric force does positive work on the proton, so its potential energy decreases. Option A is incorrect. The electric force is $F = Eq = 1.3 \times 10^5 \times 1.6 \times 10^{-19}\,\mathrm{N} = 2 \times 10^{-14}\,\mathrm{N}$. Option B is incorrect. The acceleration is $a = \frac{F}{m} = \frac{2 \times 10^{-14}}{1.67 \times 10^{-27}}\,\mathrm{m/s^2} \approx 1.2 \times 10^{13}\,\mathrm{m/s^2}$, so the acceleration time is $t = \frac{v}{a} = \frac{1.0 \times 10^7}{1.2 \times 10^{13}}\,\mathrm{s} \approx 8.3 \times 10^{-7}\,\mathrm{s}$. Option C is incorrect. The acceleration distance is $x = \frac{v}{2}t = \frac{1.0 \times 10^7}{2} \times 8.3 \times 10^{-7}\,\mathrm{m} \approx 4\,\mathrm{m}$. Option D is correct. Therefore, select D.

31. B Using the resistance formula $R = \rho\frac{L}{S}$: when length becomes 1.2 times the original, the cross-sectional area becomes $\frac{1}{1.2}$ of the original, so resistance becomes 1.44 times the original. By the closed-circuit Ohm's law, $E = U + Ir$, when total resistance increases, the circuit current I decreases, and the terminal voltage (voltage across the salt water column) U increases. Therefore A and C are incorrect, and B is correct. For D, power is given by $P = I^2 R$; without knowing the exact change in current, the power change cannot be determined, so D is incorrect. The answer is B.

32. A Looking from above downward, the conductor forms a semicircle in the magnetic field (with the distance between fixed points $2L$ as the diameter). The effective length of the conductor is $2L$, so the magnitude of the Ampere force is $F = 2BIL$. Let the tension in the conductor be T. From geometric considerations, $T = \dfrac{F}{2}$, which gives $T = BIL$. Thus A is correct and B, C, D are incorrect. Therefore, the answer is A.

33. A The average kinetic energy is proportional to temperature: $\overline{E_k} \propto T$. Charged particles in a magnetic field undergo circular motion with Lorentz force providing centripetal force: $qvB = m\frac{v^2}{R}$, giving $B = \frac{mv}{qR}$. Since $E_k = \frac{1}{2}mv^2$, we have $B = \frac{\sqrt{2mE_k}}{qR}$. With constant radius, $B \propto \sqrt{E_k} \propto \sqrt{T}$. Answer: A.

34. C Let the tree height be H and distance from mirror be L. Using the principle that the angle of incidence equals the angle of reflection, the geometric relationship gives: $\dfrac{H}{0.06} = \dfrac{L+0.4}{0.4}$. After walking forward $6.0\,\mathrm{m}$, using $\dfrac{5}{6}$ of the mirror: $\dfrac{H}{0.06 \times \frac{5}{6}} = \dfrac{L+0.4+6}{0.4}$. Solving both equations simultaneously gives $L = 29.6\,\mathrm{m}$ and $H = 4.5\,\mathrm{m}$. The answer is C.

35. B A: the potential decreases along the direction of the electric field lines, so equipotential surfaces with different potentials cannot intersect, so A is incorrect. B: from the relation between electric field lines and equipotential surfaces, electric field lines are perpendicular to equipotential surfaces, so B is correct. C: the magnitude of the electric field strength has no direct relation to the value of the potential, so the electric field strength at different points on the same equipotential surface is not necessarily equal, so C is incorrect. D: a negative charge has smaller electric potential energy at a position of higher potential, so when a negative test charge is moved from an equipotential surface at higher potential to one at lower potential, its electric potential energy increases and the electric force does negative work, so D is incorrect. The answer is B.

36. A Kepler proposed the three laws of planetary motion, stating that all planetary orbits in the solar system are elliptical, so option A is correct. Cavendish measured the gravitational constant through the Cavendish balance experiment, so option B is incorrect based on historical facts. Millikan determined the electric charge of the electron through the oil drop experiment, so option C is incorrect based on the statement. Oersted discovered the magnetic effect of electric current, so option D is incorrect based on the statement.

37. B Since the primary voltage is fixed, the secondary voltage is also fixed (determined by the turn ratio). When R increases: secondary current $I_2 = \frac{U_2}{R}$ decreases, so primary current I_1 also decreases. Secondary power $P_2 = \frac{U_2^2}{R}$ decreases, and for an ideal transformer, $P_1 = P_2$ also decreases. Answer: B.

38. B A: Electromagnetic waves can propagate in vacuum and in media. A is incorrect. B: Diffraction is a wave phenomenon; all waves undergo diffraction. B is correct. C: Transverse waves undergo polarization; electromagnetic waves are transverse waves, so they can undergo polarization. C is incorrect. D: All waves can transmit information, so electromagnetic waves can carry information. D is incorrect. Therefore, B is correct.

39. C When the sun, Earth, and moon are collinear with the Earth between the sun and moon, straight–line sunlight is completely blocked by the opaque Earth, preventing the moon from being seen from Earth; this defines a total lunar eclipse. The moon appears dark red because red light from the sun is refracted by the Earth's atmosphere and reaches the moon. Option C is correct; options A, B, and D are incorrect.

40. A The International System of Units specifies seven fundamental physical quantities: length, mass, time, thermodynamic temperature, electric current, luminous intensity, and amount of substance. Their units in the SI are called fundamental units. Option A is correct.

41. D A. As the air bag rises, the sealed gas has constant temperature. By Boyle's law, $pV = C$, when volume increases, pressure decreases; the gas does work on the external environment, not the other way around, so A is incorrect. B. When volume increases at constant temperature, pressure decreases by Boyle's law, so B is incorrect. C and D. The temperature of the gas is constant, so internal energy does not change; the gas does work on the external environment with $W < 0$. By the first law of thermodynamics, $\Delta U = Q + W$, we have $Q > 0$, meaning the gas must absorb heat from the external environment. Therefore C is incorrect and D is correct. The answer is D.

42. B A. Electric potential has only magnitude and no direction, so it is a scalar; electric field strength has both magnitude and direction, so it is a vector. A is incorrect. B. Both heat and power have only magnitude and no direction, so both are scalars. B is correct. C. Momentum has both magnitude and direction, so it is a vector; kinetic energy has only magnitude and no direction, so it is a scalar. C is incorrect. D. Both velocity and acceleration have both magnitude and direction, so both are vectors. D is incorrect. The answer is B.

43. B From Newton's second law $F = ma$, the unit of force is $\mathrm{kg} \cdot \mathrm{m} \cdot \mathrm{s}^{-2}$, so A is incorrect and B is correct. From the pressure equation $p = \dfrac{F}{S}$, force has unit $\mathrm{Pa} \cdot \mathrm{m}^2$, but Pa is not a basic unit, so C is incorrect. From the work equation $W = Fx$, force has unit $\mathrm{J} \cdot \mathrm{m}^{-1}$, but J is not a basic unit, so D is incorrect. The answer is B.

44. D During the rising process, the temperature of the gas remains constant, so internal energy remains unchanged, thus A is incorrect. The gas pressure satisfies $p = p_0 + \rho_{\mathrm{water}} gh$, so as the bubble rises, the gas pressure decreases, thus B is incorrect. By Boyle's law $pV = C$, as pressure decreases, volume increases, thus C is incorrect. As volume increases, the gas does work on surroundings. By the first law of thermodynamics $\Delta U = Q + W$, the gas absorbs heat from the water, thus D is correct. Answer: D.

45. A When the actor jumps down from a height, gravitational potential energy converts to kinetic energy, so speed increases downward and acceleration is directed downward. Playing the video backward merely reverses the trajectory but does not change the velocity and acceleration; thus the speed is greater at lower positions and acceleration is directed downward. B, C, D are incorrect; A is correct.

46. D A can be solved from the principle that gravitational force at Earth's surface equals weight. For B, C, D, use the principle that gravitational force provides centripetal force. A: Weight equals gravitational force: $\frac{GMm}{R^2} = mg$, so Earth's mass $M = \frac{gR^2}{G}$; thus A can be calculated. B: Gravitational force provides centripetal force: $\frac{GMm}{R^2} = m\frac{v^2}{R} = m\left(\frac{2\pi}{T}\right)^2 R$; we can find R from v and T, and then find Earth's mass; thus B can be calculated. C, D: Gravitational force provides centripetal force: $\frac{GMm}{r^2} = m\left(\frac{2\pi}{T}\right)^2 r$; we can find the central body's mass M from T and r, but the orbiting body's mass m cannot be found. Thus C can be solved but D cannot. The question asks for what cannot be calculated, so the answer is D.

47. D Analysis: Overweight refers to when an object's acceleration direction is upward; weightlessness refers to when acceleration direction is downward, but the motion direction is undetermined. Using Newton's second law for analysis. Solution: A and B. The object first accelerates upward and then decelerates. The acceleration first points upward and then downward. According to Newton's laws, the object first experiences overweight and then weightlessness. Thus A is incorrect and B is incorrect. C and D. When the object and hand have the same velocity and acceleration, they will not separate. Therefore, at the instant the object leaves the hand, when the object is moving upward, the object's acceleration equals gravitational acceleration. The hand must be decelerating before the instant of separation, so at this instant the hand's acceleration is greater than gravitational acceleration and points vertically downward. Thus C is incorrect and D is correct. Therefore, D is correct.

48. D Draw the light path for the two refractions. The lateral displacement is $\Delta x = \frac{d}{\cos r} \cdot \sin(i - r)$, where Snell's law gives $n = \frac{\sin i}{\sin r}$. For the same colour of light (same n), as incident angle i increases, the increase in i is faster than the increase in r, so $\sin(i - r) > 0$ and increases, and $\frac{d}{\cos r}$ also increases. Thus options A and C are incorrect. For the same incident angle, $\Delta x = d \sin i \left(1 - \frac{\cos i}{\sqrt{n^2 - \sin^2 i}}\right)$ shows that as n increases, Δx increases. Thus B is incorrect and D is correct. Therefore, D is correct.