PhysicsByAaryan

CSIR NET . GATE . JEST . BARC - Physics

Special theory of relativity - CSIR NET Physics PYQs

Classical Mechanics . All PYQs (2015-2025) with answer key

27 questions . Answer key included

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Q1. [Dec 2015] . 3.5 marks

Classical Mechanics > Special theory of relativity

CSIR NET	2015 Dec	3.5 M

Consider a particle of mass m moving with a speed v. If T_R denotes the relativistic kinetic energy and T_N its non-relativistic approximation, then the value of $\frac{(T_R - T_N)}{T_R}$ for $v = 0.01c$, is

1. 1.25×10^{-5}
2. 5.0×10^{-5}
3. 7.5×10^{-5}
4. 1.0×10^{-4}

Q2. [Dec 2015] . 5.0 marks

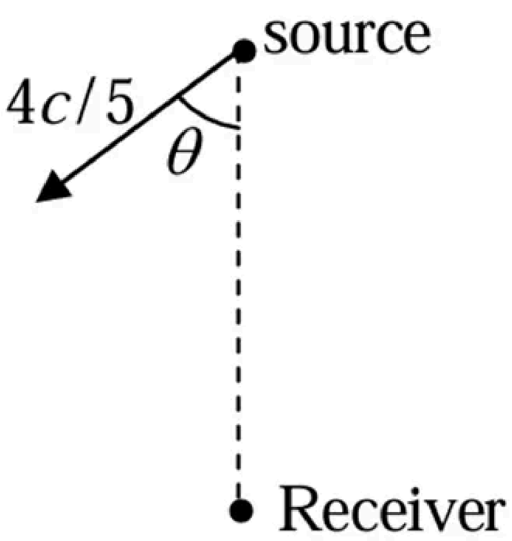
Classical Mechanics > Special theory of relativity

CSIR NET	2015 Dec	5 M

A distant source, emitting radiation of frequency ω moves with a velocity $\frac{4c}{5}$ in a certain direction with respect to a receiver (as shown in the figure). The upper cut-off frequency of the receiver is $\frac{3\omega}{2}$. Let θ the angle as

shown. For the receiver to detect the radiation, θ should at least be

Receiver



1. $\cos^{-1}\left(\frac{1}{2}\right)$
2. $\cos^{-1}\left(\frac{3}{4}\right)$
3. $\cos^{-1}\left(\frac{2}{\sqrt{5}}\right)$
4. $\cos^{-1}\left(\sqrt{\frac{2}{3}}\right)$

Q3. [June 2015] . 3.5 marks

Classical Mechanics > Special theory of relativity

CSIR NET	2015 June	3.5 M

Consider three inertial frames of reference A. B and C. The frame B moves with a velocity $c/2$ with respect to A , and C moves with a velocity $c/10$ with respect to B in the same direction. The velocity of C as measured in A is

1. $\frac{3c}{7}$
2. $\frac{4c}{7}$
3. $\frac{c}{7}$
4. $\frac{\sqrt{3}c}{7}$

Q4. [June 2015] . 5.0 marks

Classical Mechanics > Special theory of relativity

CSIR NET	2015 June	5 M

A rod of length L carries a total charge Q distributed uniformly. If this is observed in a frame moving with a speed v along the rod, the charge per unit length (as measured by the moving observer) is

1. $\frac{Q}{L}\left(1-\frac{v^2}{c^2}\right)$
2. $\frac{Q}{L}\sqrt{1-\frac{v^2}{c^2}}$
3. $\frac{Q}{L\sqrt{1-\frac{v^2}{c^2}}}$
4. $\frac{Q}{L\left(1-\frac{v^2}{c^2}\right)}$

Q5. [Dec 2016] . 3.5 marks

Classical Mechanics > Special theory of relativity

CSIR NET	2016 Dec	3.5M

A relativistic particle moves with a constant velocity v with respect to the laboratory frame. In time τ, measured in the rest frame of the particle, the distance that it travels in the laboratory frame is

1. $v\tau$

2. $\frac{c\tau}{\sqrt{1-\frac{v^2}{c^2}}}$

3. $v\tau\sqrt{1-\frac{v^2}{c^2}}$

4. $\frac{v\tau}{\sqrt{1-\frac{v^2}{c^2}}}$

Q6. [Dec 2016] . 5.0 marks

Classical Mechanics > Special theory of relativity

CSIR NET	2016 Dec	5M

Consider a radioactive nucleus that is travelling at a speed $c/2$ with respect to the lab frame. It emits γ-rays of frequency v_0 in its rest frame. There is a stationary detector (which is not on the path of the nucleus) in the lab. If a γ-ray photon is emitted when the nucleus is closest to the detector, its observed frequency at the detector is

1. $\frac{\sqrt{3}}{2}v_0$
2. $\frac{1}{\sqrt{3}}v_0$
3. $\frac{1}{\sqrt{2}}v_0$
4. $\sqrt{\frac{2}{3}}v_0$

Q7. [June 2016] . 3.5 marks

Classical Mechanics > Special theory of relativity

CSIR NET	2016 June	3.5M

Let (x, t) and (x', t') be the coordinate systems used by the observers O and O', respectively. Observer O' moves with a velocity $v = \beta c$ along their common positive x-axis. If $x_+ = x + ct$ and $x_- = x - ct$ are the linear combinations of the coordinates, the Lorentz transformation relating O and O' takes the form

1. $x'_+ = \frac{x_- - \beta x_+}{\sqrt{1-\beta^2}}$ and $x'_- = \frac{x_+ - \beta x_-}{\sqrt{1-\beta^2}}$,

2. $x'_+ = \sqrt{\frac{1+\beta}{1-\beta}}\, x_+$ and $x'_- = \sqrt{\frac{1-\beta}{1+\beta}}\, x_-$

3. $x'_+ = \frac{x_+ - \beta x_-}{\sqrt{1-\beta^2}}$ and $x'_- = \frac{x_- - \beta x_+}{\sqrt{1-\beta^2}}$,

4. $x'_+ = \sqrt{\frac{1-\beta}{1+\beta}}\, x_+$ and $x'_- = \sqrt{\frac{1+\beta}{1-\beta}}\, x_-$

Q8. [June 2016] . 5.0 marks

Classical Mechanics > Special theory of relativity

CSIR NET	2016 June	5M

For a particle of energy E and momentum $\boldsymbol{p}$ (in a frame F), the rapidity y is defined as

$y=\frac{1}{2}\ln\left(\frac{E+p_3c}{E-p_3c}\right)$. In a frame F' moving with velocity $\boldsymbol{v}=(0,0,\beta c)$ with respect to F , the rapidity y' will be

1. $y'=y+\frac{1}{2}\ln\left(1-\beta^2\right)$

2. $y'=y-\frac{1}{2}\ln\left(\frac{1+\beta}{1-\beta}\right)$

3. $y'=y+\ln\left(\frac{1+\beta}{1-\beta}\right)$

4. $y'=y+2\ln\left(\frac{1+\beta}{1-\beta}\right)$

Q9. [Dec 2017] . 3.5 marks

Classical Mechanics > Special theory of relativity

CSIR NET	2017 Dec	3.5M

A light signal travels from a point A to a point B, both within a glass slab that is moving with uniform velocity (in the same direction as the light) with speed $0.3c$ with respect to an external observer. If the refractive index of the slab is 1.5 , then the observer will measure the speed of the signal as

1. $0.67c$
2. 0.81 c
3. $0.97c$
4. c

Q10. [Dec 2017] . 5.0 marks

Classical Mechanics > Special theory of relativity

CSIR NET	2017 Dec	5M

In an inertial frame S, the magnetic vector potential in a region of space is given by $\vec{A} = az\hat{i}$ (where a is a constant) and the scalar potential is zero. The electric and magnetic fields seen by an inertial observer moving with a velocity $v\hat{i}$ with respect to S, are, respectively [In the following $\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$]

1. 0 and $\gamma a\hat{j}$
2. $-va\hat{k}$ and $\gamma a\hat{i}$
3. $v\gamma a\hat{k}$ and $v\gamma a\hat{j}$
4. $v\gamma a\hat{k}$ and $\gamma a\hat{j}$

Q11. [June 2017] . 3.5 marks

Classical Mechanics > Special theory of relativity

CSIR NET	2017 June	3.5M

An inertial observer sees two events E_1 and E_2 happening at the same location but $6\mu s$ apart in time. Another observer moving with a constant velocity v (with respect to the first one) sees the same events to be 9μ s apart. The spatial distance between the events, as measured by the second observer, is approximately

1. 300 m
2. 1000 m
3. 2000 m
4. 2700 m

Q12. [Dec 2018] . 3.5 marks

Classical Mechanics > Special theory of relativity

CSIR NET	2018 Dec	3.5M

Consider the decay $A \rightarrow B + C$ of a relativistic spin-$\frac{1}{2}$ particle A. Which of the following statements is true in the rest frame of the particle A ?

1. The spin of both B and C may be $\frac{1}{2}$
2. The sum of the masses of B and C is greater than the mass of A
3. The energy of B is uniquely determined by the masses of the particles
4. The spin of both B and C may be integral

Q13. [Dec 2018] . 5.0 marks

Classical Mechanics > Special theory of relativity

CSIR NET	2018 Dec	5M

A relativistic particle of mass m and charge e is moving in a uniform electric field of strength ε. Starting from rest at $t = 0$, how much time will it take to reach the speed $\frac{c}{2}$?

1. $\frac{1}{\sqrt{3}}\frac{mc}{e\varepsilon}$
2. $\frac{mc}{e\varepsilon}$
3. $\sqrt{2}\frac{mc}{e\varepsilon}$
4. $\sqrt{\frac{3}{2}}\frac{mc}{e\varepsilon}$

Q14. [June 2018] . 3.5 marks

Classical Mechanics > Special theory of relativity

CSIR NET	2018 June	3.5M

Two particles A and B move with relativistic velocities of equal magnitude v, but in opposite directions, along the x-axis of an inertial frame of reference. The magnitude of the velocity of A, as seen from the rest frame of B, is

1. $\frac{2v}{\left(1-\frac{v^2}{c^2}\right)}$

2. $\frac{2v}{\left(1+\frac{v^2}{c^2}\right)}$

3. $2v\sqrt{\frac{c-v}{c+v}}$

4. $\frac{2v}{\sqrt{1-\frac{v^2}{c^2}}}$

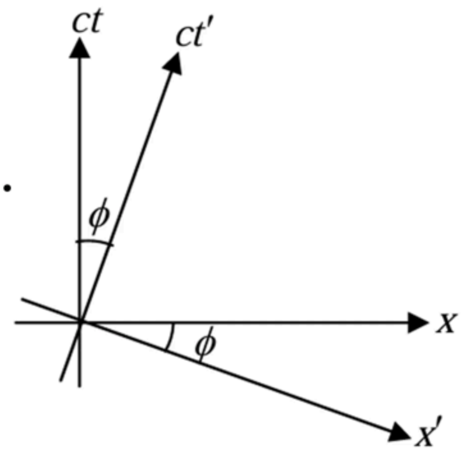
Q15. [June 2018] . 5.0 marks

Classical Mechanics > Special theory of relativity

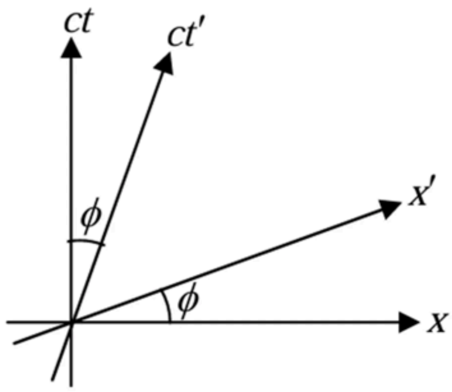
CSIR NET	2018 June	5M

An inertial frame K' moves with a constant speed v with respect to another inertial frame K along their common x-direction. Let (x, ct) and (x', ct') denote the spacetime coordinates in the frames K and K', respectively. Which of the following spacetime diagrams correctly describes the t' - axis ($x' = 0$ line) and the x' - axis ($t' = 0$ line) in the x-ct plane? (In the following figures $\tan\phi = v/c$)

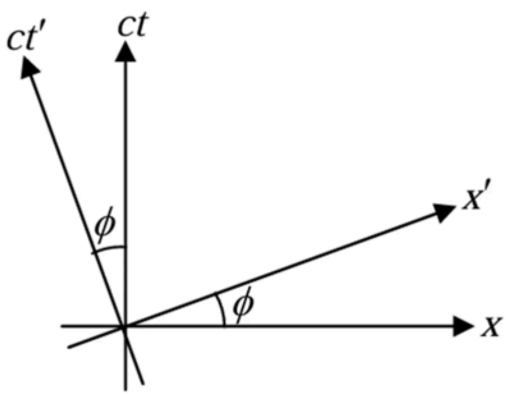
1.



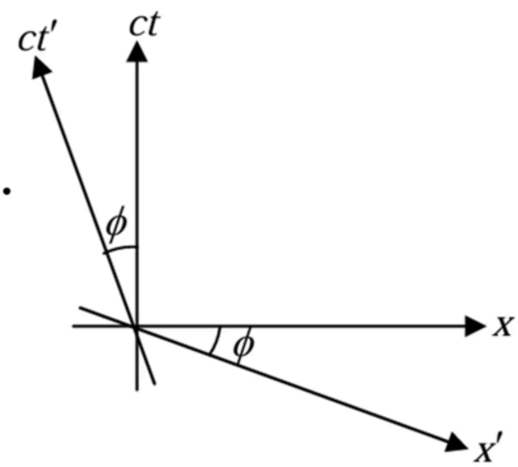
2.



3.



4.



Q16. [June 2018] . 5.0 marks

Classical Mechanics > Special theory of relativity

CSIR NET	2018 June	5M

The energy of a free relativistic particle is $E = \sqrt{|\vec{p}|^2c^2 + m^2c^4}$, where m is its rest mass, $\vec{p}$ is its momentum and c is the speed of light in vacuum. The ratio v_g/v_p of the group velocity v_g of a quantum mechanical wave packet (describing this particle) to the phase velocity v_p is

1. $|\vec{p}|c/E$
2. $|\vec{p}|mc^3/E^2$
3. $|\vec{p}|^2c^3/E^2$
4. $|\vec{p}|c/2E$

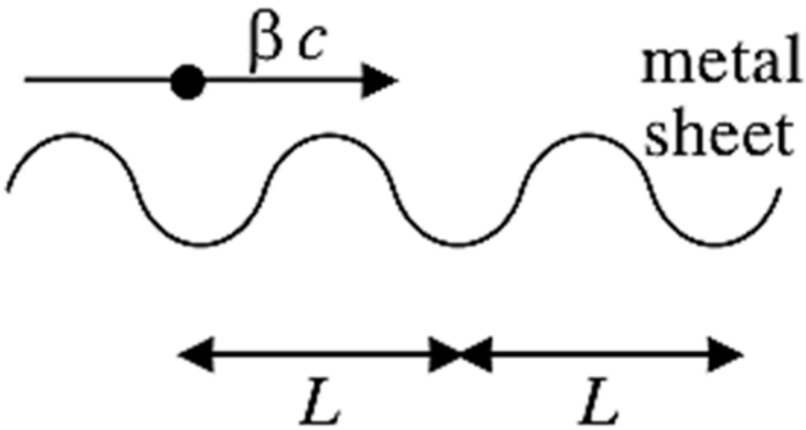
Q17. [June 2019] . 5.0 marks

Classical Mechanics > Special theory of relativity

CSIR NET	2019 June	5M

A point charge is moving with a uniform velocity βC along the positive x-direction, parallel to and very close to a corrugated metal sheet (see the figure).

The wavelength of the electromagnetic radiation received by an observer along the direction of motion is



1. $\frac{1}{\beta}\sqrt{1-\beta^2}$
2. $L\sqrt{1-\beta^2}$
3. $L\beta\sqrt{1-\beta^2}$
4. L

Q18. [June 2020] . 3.5 marks

Classical Mechanics > Special theory of relativity

CSIR NET	2020 June	3.5M

A heavy particle of rest mass M while moving along the positive z - direction, decays into two identical light particles with rest mass m (where $M > 2m$). The maximum value of the momentum that any one of the lighter particles can have in a direction perpendicular to the z direction, is

1. $\frac{1}{2}C\sqrt{M^2 - 4m^2}$
2. $\frac{1}{2}C\sqrt{M^2 - 2m^2}$
3. $C\sqrt{M^2 - 4m^2}$
4. $\frac{1}{2}MC$

Q19. [June 2021] . 3.5 marks

Classical Mechanics > Special theory of relativity

CSIR NET	2021 June	3.5M

A particle of mass $1\,\mathrm{GeV}/c^2$ and its antiparticle, both moving with the same speed v, produce new particle x of mass $10\,\mathrm{GeV}/c^2$ in a head on collision. The minimum value of v required for this process is closest to

1. 0.83c
2. 0.93c
3. 0.98c
4. 0.88c

Q20. [June 2021] . 3.5 marks

Classical Mechanics > Special theory of relativity

CSIR NET	2021 June	3.5M

A monochromatic source emitting radiation with a certain frequency moves with a velocity v away from a stationary observer A. It is moving towards another observer B (also at rest) along a line joining the two. The frequencies of the radiation recorded by A and B are V_A and V_B, respectively. If the ratio $\frac{V_B}{V_A} = 7$, then the value of v/c is

1. $1/2$
2. $1/4$
3. 3/4
4. $\sqrt{3}/2$

Q21. [June 2022] . 3.5 marks

Classical Mechanics > Special theory of relativity

CSIR NET	2022 June	3.5M

A particle of rest mass m is moving with a velocity $v\hat{k}$, with respect to an inertial frame S. The energy of the particle as measured by an observer S', who is moving with a uniform velocity $u\hat{i}$ with respect to S (in terms of $\gamma_u = 1/\sqrt{1-u^2/c^2}$ and $\gamma_v = 1/\sqrt{1-v^2/c^2}$ is

1. $\gamma_u\gamma_v m(c^2 - uv)$
2. $\gamma_u\gamma_v mc^2$
3. $\frac{1}{2}(\gamma_u + \gamma_v)mc^2$
4. $\frac{1}{2}(\gamma_u + \gamma_v)m(c^2 - uv)$

Q22. [Dec 2023] . 3.5 marks

Classical Mechanics > Special theory of relativity

CSIR NET	2023 Dec	3.5 M

The coordinates of the following events in an observer's inertial frame of reference are as follows:

Event 1: $t_1 = 0, x_1 = 0$: A rocket with uniform velocity $0.5c$ crosses the observer at origin along x axis

Event 2: $t_2 = T, x_2 = 0$: The observer sends a light pulse towards the rocket

Event 3: t_3, x_3 : The rocket receives the light pulse

The values of t_3, x_3 respectively are

1. $2T, cT$
2. $2T, \frac{c}{2}T$
3. $\frac{\sqrt{3}}{2}T, \frac{2}{\sqrt{3}}cT$
4. $\frac{2}{\sqrt{3}}T, \frac{\sqrt{3}}{2}cT$

Q23. [Dec 2024] . 3.5 marks

Classical Mechanics > Special theory of relativity

CSIR NET	2024 Dec	3.5M

A certain elementary particle is created in the upper atmosphere. It then moves downward with speed $v = 0.9999c$ with respect to an observer on earth. Its lifetime in its rest frame is 2×10^{-6}sec. The distance (in the earth's frame) travelled by the elementary particle before it decays is closest to

1. 0.6 km
2. 42 km
3. 12 km
4. 72 km

Q24. [Dec 2024] . 3.5 marks

Classical Mechanics > Special theory of relativity

CSIR NET	2024 Dec	3.5M

A particle of rest mass m_0 and energy E collides with another particle at rest, with the same rest mass. What is the minimum value of E so that after the collision, there may be four particles of rest mass m_0 ?

1. $4m_0c^2$
2. $3m_0c^2$
3. $7m_0c^2$
4. $16m_0c^2$

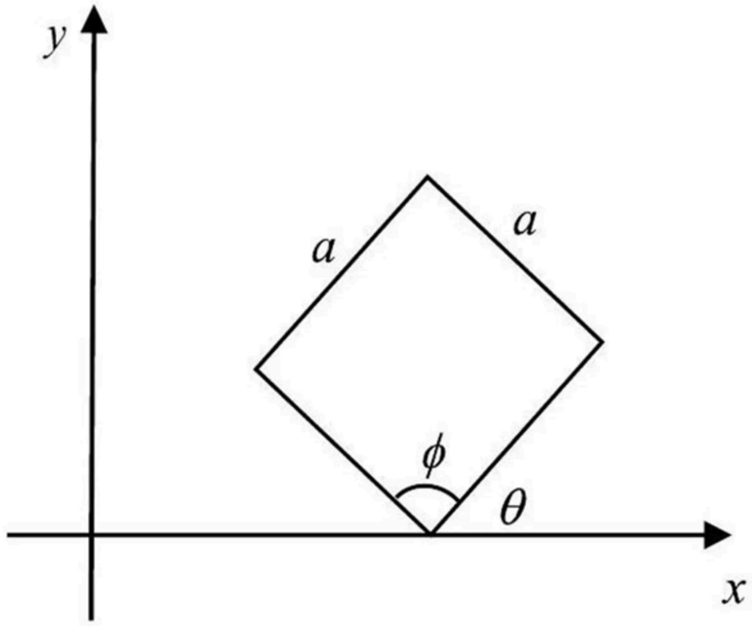
Q25. [June 2024] . 3.5 marks

Classical Mechanics > Special theory of relativity

CSIR NET	2024 June	3.5M

A square plate of dimension $a \times a$ makes an angle $\theta = \pi/4$ with the x axis in its rest frame (S) as shown in the figure. It is moving with a speed $v = \sqrt{\frac{2}{3}}C$ along the x axis with respect to an observer S' (where C is the speed of light in vacuum). The value of the interior angle ϕ indicated in the figure (which is obviously $\pi/2$ in the frame S), as measured in S' is

1. $\frac{\pi}{3}$
2. $\frac{2\pi}{3}$
3. $\frac{\pi}{6}$
4. $\frac{4\pi}{3}$



Q26. [Dec 2025] . 5.0 marks

Classical Mechanics > Special theory of relativity

CSIR NET	2025 Dec	5M	CM

In a high energy scattering experiment involving two identical particles, each of rest mass m_0, one particle is initially at rest, while the other one is incident upon it with energy E and momentum p. The total energy of the two-particle system in the centre-of-mass frame, in the limit $E \gg m_0c^2$, is approximately given by

1. E
2. $2E$
3. $\sqrt{\frac{Em_0c^2}{2}}$
4. $\sqrt{2Em_0c^2}$

Q27. [June 2025] . 5.0 marks

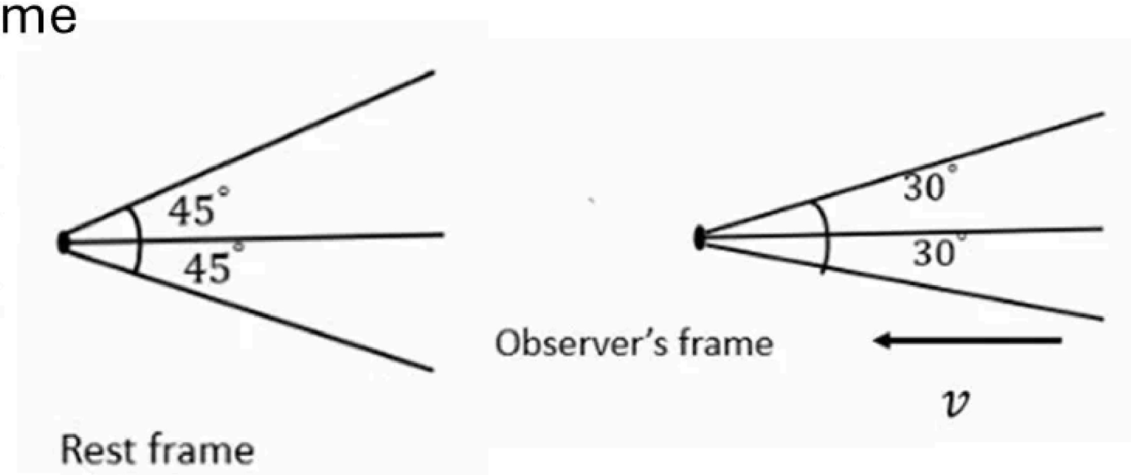
Classical Mechanics > Special theory of relativity

CSIR NET	2025 June	5M	CM

In its rest frame, a source emits light in a conical beam of width -45° to 45°. An observer is moving towards the source with a speed v. For the observer, the beam width appears to be -30° to 30°. The speed of the observer is closest to

Rest frame

1. $0.62c$
2. $0.50c$
3. $0.82c$
4. $0.41c$



Answer Key

27 questions . Subject and topic for quick revision

Q. No	Subject	Topic	Answer
Q1	Classical Mechanics	Special theory of relativity	**3**
Q2	Classical Mechanics	Special theory of relativity	**2**
Q3	Classical Mechanics	Special theory of relativity	**2**
Q4	Classical Mechanics	Special theory of relativity	**3**
Q5	Classical Mechanics	Special theory of relativity	**4**
Q6	Classical Mechanics	Special theory of relativity	**1**
Q7	Classical Mechanics	Special theory of relativity	**4**
Q8	Classical Mechanics	Special theory of relativity	**2**
Q9	Classical Mechanics	Special theory of relativity	**2**
Q10	Classical Mechanics	Special theory of relativity	**4**
Q11	Classical Mechanics	Special theory of relativity	**3**
Q12	Classical Mechanics	Special theory of relativity	**3**
Q13	Classical Mechanics	Special theory of relativity	**1**
Q14	Classical Mechanics	Special theory of relativity	**2**
Q15	Classical Mechanics	Special theory of relativity	**2**
Q16	Classical Mechanics	Special theory of relativity	**3**
Q17	Classical Mechanics	Special theory of relativity	**1**
Q18	Classical Mechanics	Special theory of relativity	**1**
Q19	Classical Mechanics	Special theory of relativity	**3**
Q20	Classical Mechanics	Special theory of relativity	**3**
Q21	Classical Mechanics	Special theory of relativity	**2**
Q22	Classical Mechanics	Special theory of relativity	**1**
Q23	Classical Mechanics	Special theory of relativity	**2**
Q24	Classical Mechanics	Special theory of relativity	**3**
Q25	Classical Mechanics	Special theory of relativity	**1**
Q26	Classical Mechanics	Special theory of relativity	**4**
Q27	Classical Mechanics	Special theory of relativity	**4**

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