1. Average velocity equals the algebraic mean of the initial and final velocities.
2. The radius of curvature of the trajectory of a particle is entirely determined by the *speed* and the *centripetal acceleration* of the particle.
3. In circular motion the acceleration vector always points towards the center of the circle.
4. If the trajectory of a particle is curved it always has a centripetal acceleration component.
5. For conservative forces the work done by the force around any closed loop is zero.
6. The direction of the force of kinetic friction is always opposite that of the acceleration.
7. Potential energy can have negative values.
8. Due to the Coriolis force, a bullet fired vertically from the Equator is deflected towards the west.
9. The reaction force of the Coriolis force acts on the rotating system.
10. The Euler force is always zero when the object is not moving in a rotating coordinate system.
11. The kinetic energy of a system of particles is independent of the work done by internal forces.
12. The torque vector is perpendicular to the corresponding force vector.
13. The angular momentum of a body is constant if the vectorial sum of the forces acting on the body is zero.
14. If an ice-skater pulls his arms in close to his body, while performing a spin, his angular momentum will increase.
15. If an ice-skater pulls his arms in close to his body, while performing a spin, his angular velocity will increase.
16. As the angular speed of a gyroscope decreases due to friction losses, the angular speed of the precession increases.
17. The amplitude of harmonic oscillations depends on the initial displacement and the initial velocity.
18. In damped oscillations the sum of the kinetic and potential energies is constant in time.
19. In damped oscillation the amplitude decreases linearly in time.
20. Forced oscillation: in case of resonance, the driving force and the body's velocity are in phase.
21. The wave function $Y(x,t) = 3\cdot\sin(-5t-6x)$ describes a wave propagating in the $(-x)$ direction.
22. A wave in a rope reflected on a fixed end undergoes a phase jump of 180°.
23. In standing waves the distance between nodes is λ.
24. A standing wave pattern can be created by two counterpropagating travelling waves.
25. Standing wave patterns can only be generated for longitudinal waves.
26. When we pluck a string on a violin, we generate longitudinal waves in the string.
27. We can never observe shock waves for light.
28. The Doppler effect has the same mathematical formula for sound and electromagnetic waves.
29. In the Doppler effect for sound waves only the relative speed between the source and the observer is important.
30. The beat frequency equals the difference between the two component frequencies.

31. The measured length of a rod cannot be larger than its proper length.

32. Length measurement is based on simultaneity.
33. The measured length contraction of a rod depends on the direction of motion of the rod.
34. According to the theory of relativity, different observers always agree about the order of two events.
35. According to the theory of relativity, different observers always agree about the order of cause and effect.
36. According to relativity, the kinetic energy of a particle cannot be larger than its rest energy.
37. According to relativistic calculations, acceleration equals the net force divided by mass.
38. Relativistic momentum equals mass times velocity.
39. In relativistic collisions total mass is conserved.
40. Relativistic momentum is inversely proportional to velocity.
41. The measured value of kinetic energy depends on the choice of the inertial frame.
42. If a spaceship moving to the right with a speed 0.7c emits a light pulse to the left, then the stationary observer measures the light pulse to move with a speed 0.3c to the left.
43. Kinetic energy equals mass times the square of the speed of light.
44. In the electromagnetic Doppler effect, the observed frequency only depends on the *relative* speed between the source and the observer.
45. In the electromagnetic Doppler effect, the wavelength of the observed light of an approaching light source is shifted towards larger wavelengths.

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1. A stone is thrown with an initial speed of 10m/s, at an angle of 30° with respect to the horizontal. Find the radius of curvature of at the initial point of its parabolic path.
(a) 6.4m (b) 8.2m (c) 11.5m (d) none

2. A particle is moving along a straight line with an acceleration of $a(t) = 10 - 3t$ [m/s^2]. At $t = 0$ the particle is at rest. Find the displacement of the particle during the first 2 seconds.
(a) 4.5m (b) 9m (c) 16m (d) none

3. The position vector of a particle is $\mathbf{r}(t) = 3t^3\mathbf{e}_x + 2t^2\mathbf{e}_y - 5t\mathbf{e}_z$ [m]. Find the magnitude of its velocity at $t = 2s$.
(a) 37.2m/s (b) 56.3m/s (c) 73.1m/s (d) none

4. A person is lifting a 2kg mass vertically with constant force. During a displacement of 2m, the work done by the person is 100J. Find the acceleration of the mass.
(a) $10m/s^2$ (b) $15m/s^2$ (c) $20m/s^2$ (d) none

5. How long does it take the 50kW engine of a car to accelerate the vehicle from 54km/h to 90km/h on a horizontal road, neglecting air resistance? The mass of the car is 1000kg.
(a) 3s (b) 4s (c) 8s (d) none

6. A ball with mass 0.1kg falls from a height of 1.25m. After colliding with the ground it bounces back to a height of 0.8m. Find the average force exerted by the ground on the ball, if the collision lasted 0.1s.
(a) 10N (b) 17N (c) 23N (d) none

7. A mass of 1kg is attached to a 1m long string and is released from rest when the string is horizontal. Find the angle between the string and the vertical when the tension in the string is 20N.
(a) 42° (b) 48° (c) 60° (d) none

8. A particle of mass m at a latitude of 30°N is moving towards the North with a velocity v. Find the magnitude and direction of the Coriolis force acting on the particle.
(a) 2mvω, West (b) mvω, North (c) mvω, East (d) none

9. The position vector of a 1kg particle is $\mathbf{r}(t) = 3t^3\mathbf{e}_x + 3t^2\mathbf{e}_y - 4t\mathbf{e}_z$. (t is measured in seconds and **r** is measured in meters.) Find the angular momentum of the particle about the origin at t=1s (in units of [kgm^2/s]).
(a) (12, −16, 2) (b) (35, 0, 15) (c) (12, −24, −9) (d) none

10. A solid cylinder is rolling down a slope with an inclination angle of 30°. Find the acceleration of the center of mass of the cylinder.
(a) g/6 (b) g/3 (c) g/2 (d) none

11. Find the instantaneous power of the torque $\boldsymbol{\tau} = 2\mathbf{e}_x + 7\mathbf{e}_y - 5\mathbf{e}_z$ at the angular velocity $\boldsymbol{\omega} = 3\mathbf{e}_x - 4\mathbf{e}_z$.
(a) 9W (b) 26W (c) 33 W (d) none

12. Find the period of a 33.6cm long rod, if it is swaying around an axis that is at a distance of 8.4cm from the top end of the rod.
(a) 0.23s (b) 0.5s (c) 0.88s (d) none

13. A 0.1kg particle is attached to a spring having a spring constant of 2.5N/m. At t=0 the displacement of the particle is −0.15m and its velocity is 1m/s. Find the amplitude of the oscillation.
(a) 0.2m (b) 0.25m (c) 0.3m (d) none

14. Two particles, both having a mass of 1kg, are hung vertically on a spring having a spring constant of 500N/m. One of the particles is suddenly cut off from the spring. Find the amplitude of the oscillations of the second particle.
(a) 1cm (b) 2cm (c) 4cm (d) none

15. A 1kg particle is attached to a spring with a spring constant of 5N/m. The particle is submerged in a liquid. Find the period of oscillation if in every 3 periods the amplitude decreases by a factor of e^6.
(a) 2.95s (b) 3.76s (c) 7.68s (d) none

16. A 0.1kg particle is attached to a spring having a spring constant of 2.5N/m. At t=0 the displacement of the particle is −0.15m and its velocity is 1m/s. Find the amplitude of the oscillation.

(a) 0.2m (b) 0.25m (c) 0.3m

17. The wave function of a specific sound wave in air is $y(x,t) = 3\cdot\sin[\pi\cdot(x-340t)]$. (All quantities have SI units.) What is the wavelength of this wave?
(a) 4m (b) 2m (c) 1m (d) none

18. A sound wave having a frequency 660Hz propagates with a speed of 330m/s. Find the phase difference between the oscillation of an air molecule 1m from the source at t = 3s, and another air molecule 4m from the source at t = 3.01s.
(a) 3.77rad (b) 2.37rad (c) 0.18rad (d) none

19. The fundamental frequency of a pipe open at both ends is 110Hz. Find the length of the pipe if the speed of sound in air is 340m/s.
(a) 0.5m (b) 1.55m (c) 3.1m (d) none

20. A tube of length 30cm is closed at one end. Find the frequency of the 2nd harmonic that can be generated, if the speed of sound in air is 340m/s.
(a) 550Hz (b) 700Hz (c) 850Hz (d) none

21. Two waves having the same amplitude are added coherently. The resultant intensity is twice the intensity of one component wave. Find the phase difference between the two component waves.
(a) 45° (b) 60° (c) 90° (d) none

22. Two waves, with oscillation periods of 0.012s and 0.011s, respectively, are added coherently. Find the beat frequency.
(a) 7.6Hz (b) 10.2Hz (c) 25.3Hz (c) none

23. A vehicle which emits a sound of constant frequency passes an observer with a speed v. The ratio between the highest and lowest observed frequencies (corresponding to the approaching and receding vehicle, respectively) is 1.2. Find the speed of the vehicle. (The speed of sound in air is 330m/s.)
(a) 20m/s (b) 30m/s (c) 40m/s (d) none

24. The frequency of the siren of an ambulance is 500Hz. Find the speed of the approaching ambulance if a stationary observer measures a frequency of 531Hz. (The speed of sound in air is 340m/s.)
(a) 15.7m/s (b) 19.9m/s (c) 25.3m/s (d) none

25. An electron moves along the +x axis with a speed of 0.9c as measured in the laboratory. A proton is moving in the same direction, but even faster than the electron. The speed of the proton is 0.7c, relative to the electron. Find the speed of the proton as measured in the laboratory.
(a) 0.916c (b) 0.982c (c) 1.6c (d) none

26. A spaceship is moving at high speed with respect to the Earth. The pilot of the spaceship measures the length of the spaceship to be 36m. According to the Earth observer the length of the spaceship is 22m. Find the speed of the spaceship.
(a) 0.79c (b) 0.66c (c) 0.12c (d) none

27. Find the ratio between the observed and the emitted frequency of a light wave, if the source is moving to the right with a speed of 0.6c and the observer is moving to the left with a speed of 0.8c (they are approaching each other).
(a) 0.76 (b) 2.3 (c) 6 (d) none

28. Two clocks on opposite sides of the Earth are synchronized. An observer on a spaceship – which is moving away from the Earth at a speed of c/2 along the line connecting the two clocks – measures the two clocks to be out of synchronization by $\Delta t'$. Find $\Delta t'$. (The radius of the Earth is 6370km.)
(a) 0.001s (b) 0.024s (c) 0.040s (d) none

29. The (x,ct) coordinates of event A and event B are A=(2,1) and B=(3,7), where all numbers are measured in meters. Find the smallest speed with which the two events can be connected.
(a) 1000km/s (b) 5000km/s (c) 50000km/s (d) none

30. The relative speed of two inertial frames, S and S', is 0.5c. At locations x_1=100m and x_2=200m (as measured in S) two light pulses are emitted simultaneously. Find the time interval between the two emission events, as measured in frame S'.
(a) 32ns (b) 87ns (c) 192ns (d) none

31. A particle having a (proper) lifetime of 3μs is travelling at a speed of 0.96c. Find the distance the particle can travel – as measured by a stationary oberver – before it is annihilated.
(a) 3.09km (b) 864m (c) 253m (d) none

32. A 100 meter long spaceship is moving to the left at a speed of 0.8c. Another, identical spaceship is moving to the right at 0.6c. Find the length of the first spaceship, as measured by an observer on the second spaceship.
(a) 11.6m (b) 32.4m (c) 68.6m (d) none

33. Two identical particles, each having a mass m, are moving in opposite directions with a speed of 0.8c. They undergo perfectly inelastic collision and stick together, creating a new, combined particle. Find the mass of the new particle.
(a) 1.5·m (b) 2·m (c) 3.33·m (d) none

34. The momentum and energy of a fast-moving particle are 0.01kg·m/s and 9MJ, respectively. Find its speed.
(a) c/4 (b) c/3 (c) c/2 (d) none

35. Find the work necessary to accelerate a particle having a mass of 1ng to a speed of 0.99c.
(a) 456J (b) 23kJ (c) 548kJ (d) none

36. The momentum of a particle is $p = \sqrt{3}mc$, where m is the particle's mass. Find the ratio between the particle's energy and its rest energy.
(a) 2 (b) 3 (c) 8 (d) none