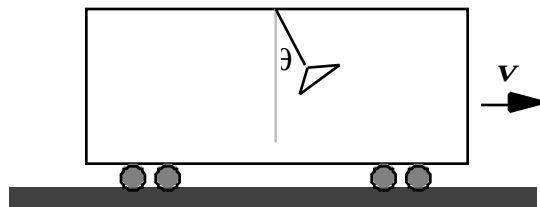


**Part A:** Multiple choice questions. Fill in your answers to these questions in Section 4 of the response form, items 1-16. Each question has a value of 4 points.

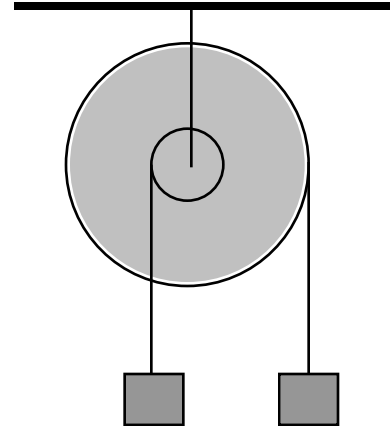
1. A complete statement of Newton's 1<sup>st</sup> law is:
- a. A body at rest stays at rest unless acted on by an external force.
  - b. It takes an external force to change the velocity of a body.
  - c. In an inertial frame, a body subject to no net external force will have no acceleration.
  - d. None of the above.
2. In motion with constant acceleration:
- a. The object must move in a straight line.
  - b. The object must be subject to zero net force.
  - c. The distance traveled is proportional to the square of the time.
  - d. The rate of change of velocity is constant.
3. A railway car with a lamp suspended from the ceiling is moving in the direction shown. The lamp cord makes angle  $\theta$  with the vertical as shown. Which of the following is **not** true?
- a. The car is accelerating to the left.
  - b. The car's acceleration has magnitude  $a = g \tan \theta$ .
  - c. The cord is along the direction of effective gravity.
  - d. The tension in the cord holding the lamp is the same as it would be if the car were not accelerating. [Greater.]



4. A crate is thrown onto a rough incline. It slides up a certain distance, stops momentarily, and then slides back down to the starting point.
- The trip up takes longer than the trip down because both gravity and friction are opposing the motion.
  - The trip down takes longer than the trip up because the average speed is less on the trip down.
  - The two trips take the same amount of time.
  - The speed at the start is the same as the speed at the finish, by conservation of energy.
5. Concerning a system of particles, which of the following is **incorrect**?
- The total kinetic energy of the system is one-half the total mass multiplied by the square of the CM speed. [Plus internal kinetic energy.]
  - If the total external force is zero the CM moves with constant velocity.
  - The location of the CM need not coincide with the location of any of the particles.
  - The total momentum is equal to the total mass times the velocity of the CM.
6. Concerning the conservation laws of mechanics:
- For total linear momentum to be conserved, the total conservative force on a system must be zero.
  - If the total external force on a system is zero, the total mechanical energy of the system is conserved.
  - If the total external force on a system is zero, the total angular momentum is conserved.
  - If any component of the total external force on a system is zero, that component of the total linear momentum is conserved.
7. In order for an object of radius  $R$  to roll without slipping on a stationary surface:
- There must be no friction.
  - The speed  $v$  of the CM and the angular speed  $\omega$  must obey  $v = R\omega$  at all times.
  - There must be no net external torque about its CM.
  - It must have constant kinetic energy.

8. In the situation shown, a heavy wheel with a small drum attached is suspended by its frictionless axle from a ceiling. Attached to strings around the rims of the wheel and drum are two blocks of equal mass. The system is originally at rest. When the blocks are released:

- a. Nothing happens, since the blocks have equal mass.
- b. The right hand block falls and the left hand one rises, with accelerations of the same magnitude.
- c. While the blocks are moving, the tension in the right hand string is less than that in the left hand string.
- d. Which block falls depends on the moment of inertia of the wheel-drum system.



9. With respect to the oscillations of a simple pendulum, which of the following is **not** true?

- a. If the length is doubled the period is doubled.
- b. The motion is approximately simple harmonic for small amplitudes.
- c. At the equator, where  $g$  is smaller, the period will be longer than in Durham.
- d. The period does not depend on the mass.

10. Two satellites of the same mass are in orbit around the earth. Satellite A is in a circular orbit of radius  $2R$ , while satellite B is in an elliptical orbit with perigee distance  $R$  and apogee distance  $3R$ .

- a. The total energy of A is greater than that of B.
- b. The angular momentum of A is greater than that of B.
- c. When B is at apogee its speed is greater than that of A.
- d. The period of B is greater than that of A.

11. Bernoulli's theorem predicts that for an ideal fluid:

- a. The pressure in a horizontal pipe will increase with increased flow speed.
- b. The pressure in a fluid flowing up an incline will increase with height.
- c. The speed of flow in a pipe will be proportional to the cross section area of the pipe.
- d. The sum of pressure, kinetic energy of flow per unit volume and gravitational potential energy per unit volume will be constant.

12. At distance  $R$  from a small sound source the loudness is given by  $\beta_1$ . At distance  $2R$  from this source, the loudness is  $\beta_2$ , where  $\beta_1 - \beta_2$  is:
- 2 db.
  - 4 db.
  - $20 \log_{10}(2)$  db.
  - $10 \log_{10}(2)$  db.
13. An ambulance approaches your moving car from behind, sounding its siren. Hearing the siren, you come to a stop to let the ambulance pass. Let the ambulance's speed be  $v_A$  and let  $v$  be the speed of sound.
- As you come to a stop, the frequency you hear from of the approaching siren is reduced.
  - While you are stopped, the frequency you hear as the ambulance approaches is higher than the actual frequency of the siren by exactly the same percent as it is lower when the ambulance is receding from you.
  - The frequencies you hear (while stopped) would be the same if the wind were blowing in the direction the ambulance moves.
  - The ratio of frequencies you hear (while stopped) as the ambulance approaches and then recedes is given by  $\frac{v + v_A}{v - v_A}$ .
14. Two harmonic waves in a medium interfere such that at a certain point the resultant intensity is zero at all times. Which of the following is **not** true?
- At the point in question, the waves must have the same amplitude.
  - There must be another point in the medium where the resultant intensity is more than the sum of the individual intensities at that point.
  - The waves must be going in the same direction. [Standing waves.]
  - The phase difference between the waves must be an odd multiple of  $\pi$ .
15. An ideal gas expands in an isothermal process.
- No heat is taken in.
  - No work is done.
  - There is no change in entropy.
  - There is no change in internal energy.

16. A heat engine operates between reservoirs at 300 K and 250 K. In each cycle it takes heat 300 J from the hot reservoir.
- The net entropy change per cycle of the engine itself is 1 J/K.
  - The engine's efficiency is 1/5.
  - At least 250 J of heat must be expelled to the cold reservoir. [2<sup>nd</sup> law.]
  - None of the above is true.

**Part B:** True-false questions. Fill in your answers to these questions in Section 4 of the response form, items 17-28. Mark "A" for true, "B" for false. Each question has a value of 3 points.

17. If a car makes a round trip, traveling out 10 km in 10 minutes and back along a different route in 8 minutes, its average velocity is zero. **T**
18. If you lift a weight from rest on the floor and put it at rest on your shoulders, the total work done on the weight by all forces is zero. **T**
19. In a collision between a large sport-utility vehicle (SUV) and a compact car, the magnitude of the force exerted on the car by the SUV is larger than that exerted on the SUV by the car. **F** [Same.]
20. When you unscrew the top of a bottle, your thumb and fingers exert opposing forces but parallel torques. **T**
21. As an object rolls without slipping down an incline, the ratio of rotational kinetic energy to translational kinetic energy decreases. **F** [Same.]
22. The resonant frequency of a driven oscillator is the frequency at which it would oscillate freely and without damping. **T**
23. In the figure, a pair of equal masses attached to a spring is falling freely toward a massive star; as the system gets closer to the star, the spring stretches more. **T** [Tidal forces.]



24. The pressure in the water coming out of the nozzle of a horizontal fire hose is higher than the pressure in the water at points back inside the hose. **F** [Less.]
25. After passing through a filter that eliminates all frequencies above 1000 Hz, the sounds of a flute and an oboe both playing a musical note with fundamental frequency 512 Hz will be indistinguishable. **T** [No higher harmonics heard.]
26. If a guitar string is plucked exactly in its middle, the resulting vibration will consist only of the odd-numbered harmonics. **T**
27. When two waves interfere destructively the energy in the waves is converted to heat. **F**
28. Nighttime temperatures in desert areas are generally lower than those in nearby areas with normal vegetation because the cloudless skies in the desert allow rapid heat loss by radiation. **T**