Name: Rec. Instr.: Rec. Time:

Make your work clear to the grader. Show the formulas you use, all the essential steps, and results with **correct SI units** and correct **significant figures**. Partial credit is available if your work is clear. For MC questions, choose the best answer. All question parts **are worth 4 points**. There are 220 maximum points possible.

Unless otherwise requested, **give results in SI units** (with prefixes if convenient).

Conversions: 1 inch = 2.54 cm, 1 ft = 12 in = 0.3048 m, 1 mile = 5280 ft, 1 lb. = 4.45 N, Speed of sound in air (20°C): 343 m/s, 1 hp = 746 W, G = 6.67×10^{-11} N m^2/kg^2, g = 9.80 m/s^2, R = 8.314 J/mol·K, $N_A = 6.022 \times 10^{23}$/mol, 1 u = 1.6605×10^{-27} kg, $k_B = 1.38 \times 10^{-23}$ J/K, 1 cal = 4.186 J, 1 atm = 101.3 kPa.

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1. (4) Express the speed of light (2.9979×10^8 m/s) in ft/ns (feet per nanosecond).

2. (4) If a car is moving along a winding road at constant speed, which of these quantities is zero?

a. its displacement. b. its velocity. c. its acceleration.
d. its change in kinetic energy. e. none of the other choices.

3. (4) If a car is travelling along some x-axis and is slowing down, its acceleration is along

a. $-x$. b. $+x$. c. $-y$. $+y$. e. some other axis not listed.

4. (4) Which of the following controls can be used to make a car accelerate?

a. the steering wheel. b. the gas pedal. c. the brake pedal.
d. all of the choices a,b & c. e. none of the other choices.

5. (4) When a mass travels in a circle at constant speed, its acceleration

a. is zero because the speed is constant. b. points along the arc of the circle.
c. points away from the circle's center. d. points towards the circle's center.

6. (4) If you separately weigh some objects and get the three measurements, $w_1 = 1.60$ N, $w_2 = 125$ N and $w_3 = 2.40$ kN, what is their total combined weight (to correct significant figures)?

7. (4) Estimate the **area** of the largest circle that a typical adult could run around once in 1.00 hour.

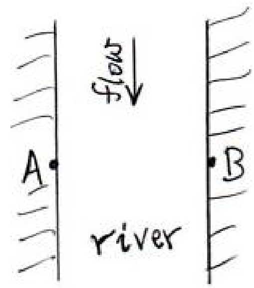
8. (4) You throw a baseball straight up in the air and it comes back to the launch point in 2.5 seconds. Which quantity would have to be doubled to make it stay in the air for twice as long?

a. the ball's initial speed.
b. the ball's initial kinetic energy.
c. the ball's initial potential energy.
d. the ball's mass.

9. (4) You throw a baseball straight up in the air and it reaches a peak height of 15 m above the launch point. Which quantity would have to be doubled to make it rise twice as high above the launch point?

a. the ball's initial speed.
b. the ball's initial kinetic energy.
c. the ball's initial potential energy.
d. the ball's mass.

10. (8) A 1.00-km wide river is flowing uniformly due south at 5.00 km/h. You want to drive your boat from the west shore (A) to a point on the other shore due east from your initial point (B). Your boat's speed relative to the water is 10.0 km/h.



a) (4) In what direction (expressed using points on the compass) should the boat be pointed so that its net velocity relative to the shore is due east?

b) (4) How long will it take to cross the river that way?

11. (4) When a projectile's launch speed is doubled, its range over level ground (for any launch angle) will be changed by a factor of: a. 1 (unchanged). b. $\sqrt{2}$ c. 2 d. 4 e. other.

12. (4) Fred takes a walk in downtown New York, first going 5.0 blocks due east, then turning to go 7.0 blocks due south, and then finally 9.0 blocks due west. How far (as the crow flies) is he from his starting point, in blocks?

13. (4) A 1600-kg car accelerates uniformly at 0.80 m/s^2 on a straight road. Initially, its speed is 24 km/h. How long will it take for the car to reach a speed of 96 km/h?

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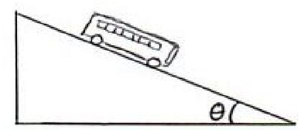
14. (8) A 5600-kg bus is descending a 12.0° incline initially at 25.0 m/s. The coefficients of friction between tires and road are $\mu_s = 0.800$ and $\mu_k = 0.600$.



a) (4) What is the magnitude of the maximum deceleration if the brakes are applied?

b) (4) While braking, the net force on the bus is in which direction?

a. vertically up. b. vertically down. c. up along the incline. d. down along the incline.
e. perpendicular to the incline, out of the pavement. f. perpendicular to the incline, into the pavement.
g. none of the above because the net force is zero.

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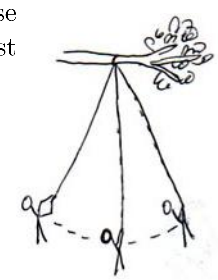
15. (8) Tarzan (85 kg) is swinging back and forth while hanging on a vine 5.0 m long. Suppose friction is negligible and he keeps swinging easily for a long time. When he passes the lowest point, his speed is 8.0 m/s.

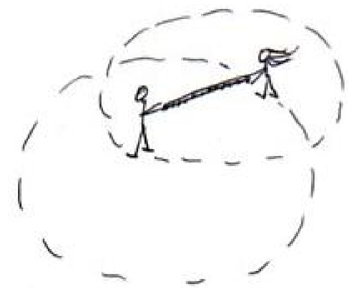


a) (4) How large is the vine tension when he's at the lowest point?

b) (4) To what maximum height does he swing up above the lowest point?

16. (20) Now Tarzan (85 kg) and Jane (55 kg) are skating on level frictionless ice (it's a very cold jungle), moving in uniform circular motion by holding on to opposite ends of a vine. They circle once every 3.4 s.

a) (4) At any instant, the magnitude of the net force acting on Jane is



a. zero.
b. greater than the magnitude of the net force on Tarzan.
c. equal to the magnitude of the net force on Tarzan.
d. less than the magnitude of the net force on Tarzan.

b) (4) At any instant, the magnitude of Jane's acceleration is

a. zero.
b. greater than the magnitude Tarzan's acceleration.
c. equal to the magnitude of Tarzan's acceleration.
d. less than the magnitude of Tarzan's acceleration.

c) (4) Which "conservation law" explains why Jane's circular path has larger radius than Tarzan's?

a. conservation of energy. b. conservation of momentum.
c. conservation of angular momentum. d. conservation of mass.

d) (4) Jane's circular path has radius 1.80 m. How large is the magnitude of her centripetal acceleration?

e) (4) If Tarzan and Jane move towards each other (while still circling around) by pulling themselves inward along the vine, which one of the following does not change?

a. their period of orbit. b. their angular speed.
c. their rotational kinetic energy. d. their angular momentum.

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17. (4) A 1680-kg car can accelerates from rest to 136 km/h (37.8 m/s) on a level road in 11.2 s. What is the minimum required power output of the engine, in kW?

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18. (8) A 98 kg football player catches a horizontally moving 0.42 kg football, bringing it to rest in 0.25 s. The average horizontal force of the ball on the player's hands was 45 N.

a) (4) What was the magnitude of the impulse on the football?

b) (4) What was the initial speed of the football?

19. (8) The starship Enterprise ($m = 3200$ kg) has discovered a new planet called Zoron: they find themselves in a circular orbit around it of radius 8800 km and period 15.5 hours.

a) (4) What is the orbital speed of Enterprise, in m/s?

b) (4) Apply Newton's Law of Universal Gravity and his Second Law of Mechanics to find the mass of Zoron.

20. (4) A building has 12 stories; the uppermost floor is 40.0 m above the point where the water main enters the building. To ensure a gauge pressure of 1.00 atm at the uppermost floor, what gauge pressure is needed in the water main?

21. (4) Inside a house the pressure is 1.00 atm. If a strong gust of wind blows parallel to a window, the pressure on the outer surface of the window will be

a. less than 1.00 atm. b. 1.00 atm. c. more than 1.00 atm. d. no way to know.

22. (4) A cube of side 10.0 cm is made of aluminum (SG=2.70). Under normal atmospheric pressure, how large is the pressure force on one of its faces?

23. (4) A pendulum made from a 0.250 kg mass suspended on a cord is oscillating with a frequency of 1.25 Hz. How long is the cord?

24. (4) When a mass connected to a spring is oscillating between points $x = -12.0$ cm and $x = +12.0$ cm, at which point(s) will the speed be maximum?

a. $x = 0$. b. $x = \pm 7.2$ cm. c. $x = \pm 12.0$ cm d. some other value(s).

25. (8) A 42.0 cm long string is vibrating at 1320 Hz in a standing wave with three loops.

a) (4) What is the speed of the waves on the string?

b) (4) What is the fundamental resonance frequency of the string?

26. (4) **T** **F** Sound waves in air travel faster when the temperature is higher.

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28. (4) You are given two organ pipes: Pipe A is 1.0 m long, open at both ends. Pipe B is 0.5 m long, open at one end and closed at the other. Which has the higher fundamental resonance frequency?

a. pipe A. b. pipe B. c. it's a tie. d. not enough information is given to decide this.

29. (4) A piano string vibrates and produces sound in the air. What property of the waves in air is the same for the waves on the piano string?

a. wavelength. b. frequency. c. intensity. d. speed. e. none of the other choices.

30. (4) Air at STP contains a mixture of O_2, N_2, H_2O, CO_2, etc. What property is the same for them all?

a. molecular speeds. b. molecular rms speeds. c. instantaneous KE_{trans}. d. average KE_{trans}.

31. (8) A container holds 8.00 grams of helium gas at 1.00 atm and 295 K. It can be considered an ideal gas.

a) (4) How many moles of helium are present?

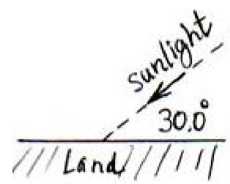
b) (4) How much internal energy is present in the gas, in joules?

32. (8) A 1.00 kg piece of metal initially at 100°C in thrown into an insulated container holding 4.00 L water initially at 0°C. After a short time, the final temperature of both is 12.0°C.

a) (4) Find the heat absorbed by the water.

b) (4) Find the specific heat of the metal.

33. (4) On a clear day the sunlight intensity at Earth's surface is 1.00 kW/m^2. If the Sun is 30.0° above the horizon, how much energy is absorbed in 1.00 minute by one hectare of land (10^4 m^2), whose emissivity is 0.75?



34. (16) The PV diagram indicates a sequence of processes (AB, BC, CA) applied to an ideal gas in an engine, with pressure in atmospheres and volume in liters (1 L = 10^{-3} m^3).

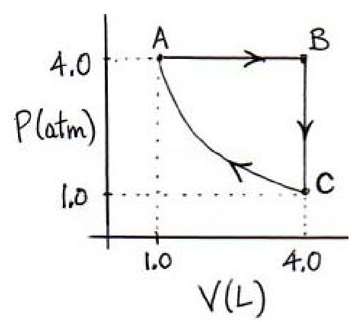
a) (4) Which process is an isothermal compression?

a. AB b. BC c. CA d. there isn't one.

b) (4) Which process is an isobaric compression?

a. AB b. BC c. CA d. there isn't one.

c) (4) Find the work done by the gas in process AB.



d) (4) If the temperature of the gas is 280 K at point A, what is its temperature at point B?

35. (12) 1.40 moles of ideal gas expands adiabatically, doing 4200 J of work on its surroundings.

a) (4) The heat transfered to the gas is a. -4200 J b. 0 J c. 4200 J. d. other.

b) (4) The internal energy change of the gas is a. negative b. zero c. positive.

c) (4) The temperature change of the gas is a. negative b. zero c. positive.

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36. (12) A household central air conditioning system keeps the interior of a house at 22°C while the outdoor temperature is 38°C. It uses 440 W of eletric power to produce a "cooling power" of 3200 W.

a) (4) How large is the system's coefficient of performance?

b) (4) At what average rate is exhaust heat leaving the compressor unit outside the house?

c) (4) If the system could be replaced by an ideal "Carnot AC system," what electric power would be needed to get the same cooling power of 3200 W?