

**Final Exam  
Phys 220  
2012**

Name: Solution Group: \_\_\_\_\_

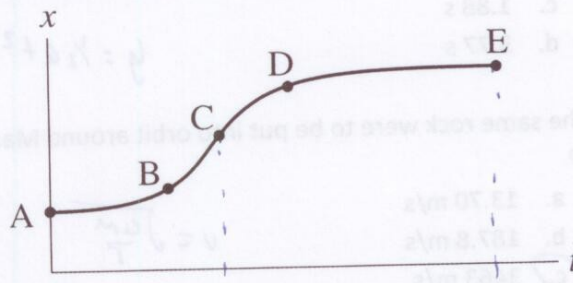
Questions 1-26 are worth 4.5 points each

- If an object has a negative velocity and a negative acceleration, it means the object will
  - slow to a stop.
  - ☒ speed up.
  - slow down, turn around and speed up in the other direction
  - remain at a constant speed

- When a ball is thrown up into the air, what is its acceleration at the top of its flight?

- $a = 0 \text{ m/s}^2$
- ☒  $a = -9.8 \text{ m/s}^2$
- $a = 9.8 \text{ m/s}^2$
- Not enough information is given.

**Questions 3 - 5** The plot to the right shows the position of an object as a function of time. The letters A-E represent particular moments of time.



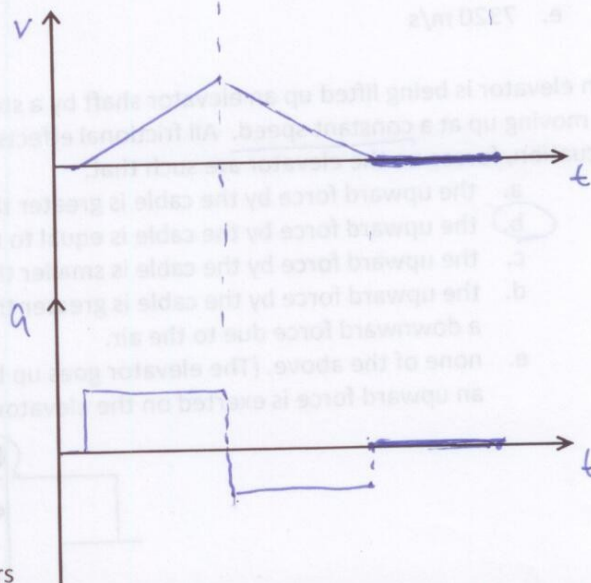
- At which moment in time is the speed of the object the highest?

- A
- B
- ☒ C
- D
- E

- At instant E the velocity of the object is

- positive
- negative
- ☒ zero
- Not enough info

- Sketch the corresponding velocity vs. time and acceleration vs. time graphs for the graph shown.



- Shown here are the velocity and acceleration vectors for an object in several different types of motion. In which case is the object speeding up and turning to its left?

a.



b.



☒ c.



d.



e.



7. A bus is moving at 15.0 m/s relative to the Earth. A passenger in the bus throws a ball to his friend. If the ball is thrown with a horizontal velocity of 3.0 meters per second relative to the Earth, what is its velocity relative to the bus?

- a. -12.0 m/s
- b. -18.0 m/s
- c. 12.0 m/s
- d. 18.0 m/s

$$V_{BE} = 15.0 \text{ m/s}$$

$$V_{bE} = 3.0 \text{ m/s}$$

$$V_{bB} = V_{bE} + V_{EB}$$

$$= 3.0 \text{ m/s} + -15.0 \text{ m/s}$$

$$= -12.0 \text{ m/s}$$

Questions 8-9: The back of your text says: Mars has a mass of  $6.42 \times 10^{23}$  kg, it is  $2.28 \times 10^{11}$  m from the sun, it has a radius of  $3.37 \times 10^6$  m and it takes Mars 1.88 years to orbit the sun.

8. Find the time it takes for a rock to fall 2.0 meters on Mars.

- a. 0.67 s
- b. 1.03 s
- c. 1.88 s
- d. 3.77 s

$$g = \frac{GM}{r^2} = 3.77 \text{ m/s}^2$$

$$y = \frac{1}{2}at^2$$

9. If the same rock were to be put into orbit around Mars at an altitude of 200,000 m, what would its speed be?

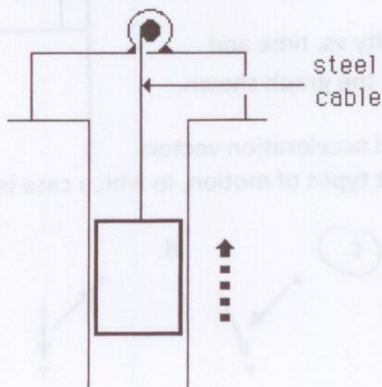
- a. 13.70 m/s
- b. 187.8 m/s
- c. 3463 m/s
- d. 3565 m/s
- e. 7320 m/s

$$v = \sqrt{\frac{GM}{r}}$$

$$r = 3.37 \times 10^6 + 200,000 = 3.57 \times 10^6 \text{ m}$$

10. An elevator is being lifted up an elevator shaft by a steel cable as shown in the figure below. The elevator is moving up at a constant speed. All frictional effects including air resistance are negligible. In this situation, forces on the elevator are such that:

- a. the upward force by the cable is greater than the downward force of gravity.
- b. the upward force by the cable is equal to the downward force of gravity.
- c. the upward force by the cable is smaller than the downward force of gravity.
- d. the upward force by the cable is greater than the sum of the downward force of gravity and a downward force due to the air.
- e. none of the above. (The elevator goes up because the cable is being shortened, not because an upward force is exerted on the elevator by the cable).





11. A constant horizontal force,  $F$ , is applied on a large box. As a result, the box moves across the floor at a constant speed.

If the applied force is doubled, the box then moves:

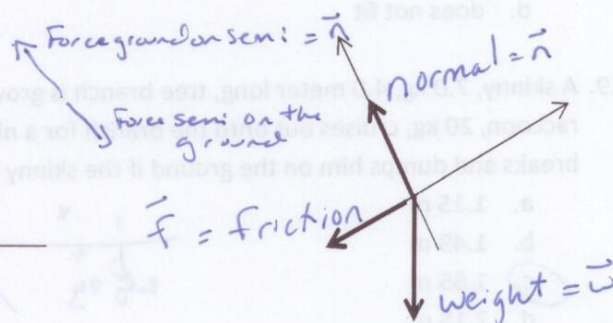
- with a constant speed that is double the speed when only the force,  $F$ , was applied.
- ☒ with a continuously increasing speed.
- with a constant speed that is greater than the speed when only the force,  $F$ , was applied, but not necessarily twice as great.
- for a while with a speed that is constant and greater than the speed when only the force,  $F$ , was applied, then with a speed that increases thereafter.
- for a while with an increasing speed, then with a constant speed thereafter.

**Questions 12 and 14:** You are explaining to a friend about normal forces, weight and force pairs. To illustrate "action reaction" force pairs you pick the semi problem from exam 2. A semi's brakes fail as it heads down I-70. Luckily there's a runaway truck ramp near. The semi goes up the ramp and the deep gravel quickly brings the truck to a stop. You show them that the free body diagram below fits this description.

12. Label each force shown in this diagram. (write the entire word not just the one letter abbreviation).

13. The correct force pair for the normal force is

- Ground on the semi (contact force)
- ☒ Semi on the ground (contact force)
- Semi on the Earth (long range force)
- Earth on the semi (long range force)
- Other \_\_\_\_\_



14. The correct force pair for the weight is

- Ground on the semi (contact force)
- Semi on the ground (contact force)
- ☒ Semi on the Earth (long range force)
- Earth on the semi (long range force)
- Other \_\_\_\_\_

↑ Semi on Earth

↓  $\vec{w}$  = Earth on Semi

15. The rotational equivalent of mass is

- angular acceleration
- angular momentum
- ☒ moment of inertia
- angular velocity
- torque

16. Momentum is conserved

- always
- ☒ if there is no outside force acting
- only if the collision is perfectly elastic
- only if the collision is perfectly inelastic
- other not listed above: \_\_\_\_\_

17. Why does the squishy interior of a ram's skull allow it to butt heads with another ram without causing a concussion?

- a. it reduces the force
- b. it reduces the impulse
- c. it reduces the time of impact
- d. It spreads the force out over time
- e. It spreads the force out over a larger area of the skull

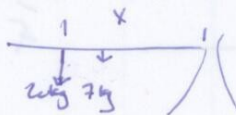
18. When our legs bear our weight, the bones compress slightly. Based on our model of stretching and compressing, where does the weight of our bodies fit? The model is stress equals Young's modulus times the strain:

$$\frac{F}{A} = Y \frac{\Delta L}{L}$$

- a. stress
- b. Young's modulus
- c. strain
- d. does not fit

19. A skinny, 7.0 kg, 4.0 meter long, tree branch is growing straight out, horizontal to the ground. A fat raccoon, 20 kg, cruises out onto the branch for a nice juicy peach. How far can he go before the branch breaks and dumps him on the ground if the skinny little branch can handle a total of 500 Nm of torque?

- a. 1.15 m
- b. 1.49 m
- c. 1.85 m
- d. 2.15 m
- e. 2.85 m



$$500 \text{ Nm} = 20 \text{ kg} \cdot 9.8 \text{ m/s}^2 \cdot x + 7 \text{ kg} \cdot 9.8 \text{ m/s}^2 \cdot 2.0 \text{ m}$$

$$x = 1.85 \text{ m}$$

**Questions 20 – 21:** Two vehicles collide head on. Initially the first vehicle is traveling at 10.0 m/s due North and the second vehicle, which is *twice* the mass of the first, is traveling due South at 10.0 m/s. Immediately after the collision, the first vehicle is stationary.

20. Determine the final velocity of the second vehicle?

- a. -5.0 m/s
- b. -10.0 m/s
- c. 15.0 m/s
- d. 30.0 m/s

$$10 \text{ m} + -1(2 \text{ m}) = 0 \text{ m} + v_f 2 \text{ m}$$

$$\frac{-10 \text{ m}}{2 \text{ m}} = v_f \quad v_f = -5 \text{ m/s}$$

• South @ 5 m/s

21. What is the impulse delivered to each vehicle?

- a. -5.0 m/s m, 5.0 m/s m
- b. -5.0 m/s m, 0 m/s m
- c. -10 m/s m, 10 m/s m
- d. -10 m/s m, 20 m/s m

$$\vec{J} = \Delta p = m(v_f - v_i)$$

$$= m(0 - 10)$$



22. A one mole sample of neon ( $3.324 \times 10^{-26}$  kg/molecule) is at  $20^\circ\text{C}$  and is considered to behave ideally. What is the average kinetic energy per molecule?

- a.  $4.14 \times 10^{-22}$  J
- ☒ b.  $6.065 \times 10^{-21}$  J
- c. 158 J
- d. 604 J
- e. 3649 J

$$K = \frac{3}{2} k_B T$$

$$T = 293 \text{ K}$$

23. What is the rms speed of a helium molecule ( $3.324 \times 10^{-26}$  kg) at room temperature,  $20^\circ\text{C}$ ?

- a.  $4.14 \times 10^{-22}$  m/s
- b.  $6.065 \times 10^{-21}$  m/s
- c. 158 m/s
- ☒ d. 604 m/s
- e. 3649 m/s

$$v = \sqrt{\frac{3k_B T}{m}}$$

24. A waterfall is 500 m high. If all the gravitational potential energy of the water were converted into thermal energy, by how much would the temperature of the water increase after hitting the water at the bottom of the falls?

- a. 0.1 degrees
- b. 0.5 degrees
- ☒ c. 1 degree
- d. 5 degrees
- e. Not enough information

$$mgh = mc\Delta T$$

$$\frac{gh}{c} = \Delta T = 1.17^\circ\text{C or } 1.17 \text{ K}$$

25. An insulated container holds a combination of ice and water in thermal equilibrium at atmospheric pressure. What is the temperature of the water?

- ☒ a.  $0^\circ\text{C}$
- b.  $< 0^\circ\text{C}$
- c.  $> 0^\circ\text{C}$
- d.  $100^\circ\text{C}$
- e. Not enough information

26. If a person measures their blood pressure in the following two positions, the readings will be

- a. Higher for A
- ☒ b. Higher for B
- c. The same at both positions.



A



B

more pressure deeper in the body

Questions 27 – 29 are worth 16 points each – **All work must be shown for credit**

27. A cat leaps to catch a bird. If the cat's jump was at an angle of  $40.0^\circ$  off the ground and its initial velocity was  $7.0 \text{ m/s}$ , will it catch a bird if the bird is  $1.0 \text{ meters}$  above the ground?

x  $y_i = 0$

$y_f = ?$

$v_{yi} = 7.0 \sin 40^\circ = 4.5$

$v_{yf} = 0$

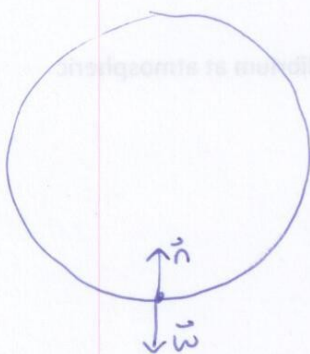
$a = -9.8$

$v_f^2 = v_i^2 + 2a\Delta y$

$\frac{v_f^2}{2a} = \Delta y$

$1.03 \text{ m}$  no problem!

28. A  $50 \text{ kg}$  person is on a Ferris wheel with a radius of  $30 \text{ meters}$ . The Ferris wheel is traveling at  $0.35 \text{ radians per second}$ . Determine the person's apparent weight as they reach the lowest point in the ride. Show all work including a free body diagram and sum of forces that you use to calculate the apparent weight.



$\Sigma F = n - w = ma$

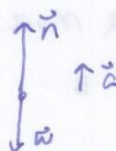
$n = w + ma$

$= mg + ma$

$= mg + m\omega^2 r$

$= 50 \text{ kg } 9.8 + 50 \text{ kg } (0.35)^2 30$

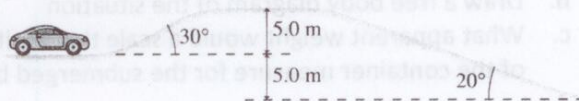
$= \boxed{674 \text{ N}}$





29. The car in the figure to the right has a mass of 1200 kg. The car suddenly runs out of gas while traveling at 12 m/s, rolls over the hill and is traveling at 10 m/s at the bottom of the hill on the far right. He travels 40 meters during this time.

- How much energy was converted to thermal energy?
- How much work is done by friction?
- What is the average force of friction?



$$K_i + U_i = K_f + U_f + E_{TH}$$

$$\frac{1}{2}mv_i^2 + mgh = \frac{1}{2}mv_f^2 + 0 + E_{TH}$$

$$\frac{1}{2}m(v_i^2 - v_f^2) + mgh = E_{TH}$$

$$26,400 + 58,800 = 85,200 \text{ J}$$

$$b. \quad -85,200 \text{ J}$$

$$c. \quad W = F \cdot \Delta x$$

$$F = \frac{W}{\Delta x} = \frac{-85,200}{40} = -2135 \text{ N}$$

30. (6 points) What is the pressure difference between two points in a container of water 0.30 m from the surface of the water and 0.40 m from the surface? Show all your work and clearly specify at which point the pressure is higher.

$$P_A = P_0 + \rho g d_A$$

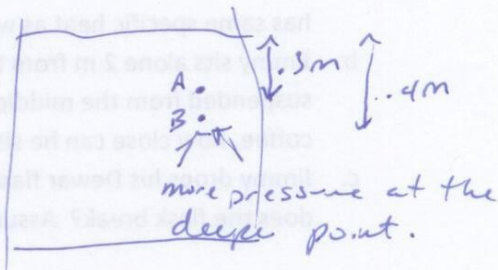
$$P_B = P_0 + \rho g d_B$$

$$P_A - P_B = P_0 + \rho g d_A - (P_0 + \rho g d_B)$$

$$= \rho g (d_A - d_B)$$

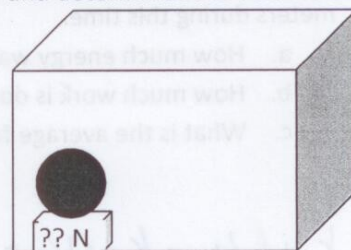
$$= \rho g (0.3 - 0.4)$$

$$= -980 \text{ Pa}$$

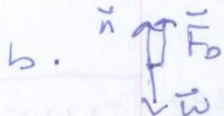


31. (9 points) A student demonstrates that a bowling ball of mass 7.0 kg sinks. The student carefully measures the increase in water level when the bowling ball is placed in the container and determines the volume of water that the ball displaced is  $0.0054 \text{ m}^3$ . Volume of a sphere is  $\frac{4}{3} \pi r^3$ .

- What is the mass of the water that is displaced?
- Draw a free body diagram of the situation
- What apparent weight would a scale that is sitting on the bottom of the container measure for the submerged ball?



a.  $\frac{m}{V} = \rho \quad m = \rho V = 1000 \text{ kg/m}^3 \cdot 0.0054 \text{ m}^3 = \underline{5.4 \text{ kg}}$



$\Sigma F = F_b + n - w = 0$

c.  $n = w - F_b = 7.0 \text{ kg} \cdot 9.8 - 5.4 \text{ kg} \cdot 9.8 = \underline{15.7 \text{ N}}$

32. (20 points – show all work) Student created bonus question from 2011:

Story: A coffee shortage

Jimmy is a welder during a giant coffee shortage. He is the only welder to bring coffee in on a Monday morning. He brings enough coffee for he and his friend in a Dewar flask (empty mass of 0.50 kg).

- If he has 12 cups (assume 0.25 kg / cup) of coffee at  $100^\circ\text{C}$  and has 1 kg of ice ( $0^\circ\text{C}$ ) to cool it off, will he and his fellow members be able to chug their much-needed caffeine? Assume that coffee has same specific heat as water.
- Jimmy sits alone 2 m from the center on a 10 m I-beam that weighs 500 kg. The I-beam is suspended from the middle of the beam. If his friend, Will, wants to sit with Jimmy and share coffee, how close can he sit? Assume Jimmy weighs 85 kg and Will weighs 80 kg.
- Jimmy drops his Dewar flask of coffee from the beam 25 m up. If the Dewar flask breaks at 100 N, does the flask break? Assume the time of contact with the ground is 0.20 seconds

$Q_{\text{lost}} + Q_{\text{gained}} = 0$

$m_{\text{coffee}} \Delta T + m_{\text{ice}} \Delta T + m_{\text{c}} \Delta T$

$3 \text{ kg} \cdot 4186 (T_f - 100^\circ\text{C}) + 1 \text{ kg} \cdot 3.33 \times 10^5 \text{ J} + 1 \text{ kg} \cdot 4186 (T_f - 0^\circ\text{C}) = 0$

$12558 T_f - 1,255,800 \text{ J} + 333,000 \text{ J} + 4186 T_f - 0 = 0$

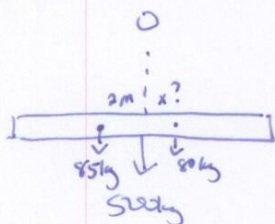
$16744 T_f - 922,800 \text{ J} = 0$

$T_f = 55^\circ\text{C}$  or  $131^\circ\text{F}$  ← pretty hot but probably fine to sip



33. Bonus Question: This question is optional and worth up to an additional 20 points on your final exam score. The question is due by Friday 12/14/12.

Write a possible final exam problem for this course that contains concepts from three or more chapters combined in a way that has not been done in previous homework, quiz or exam questions this semester. A correct solution must accompany the problem.



$$x_{cm} = 0 = \frac{85kg(-2) + 80kg x}{500 + 85 + 80}$$

$$x = 2.125 \text{ m on the other side of the beam.}$$

C. Find velocity before impact  
Then impulse and then force

$$mgh = \frac{1}{2}mv^2$$

$$\sqrt{2gh} = v = \sqrt{2 \cdot 9.8 \cdot 2.5} = 19.9$$

$$v = 22.1 \text{ m/s}$$

I'm assuming it's full of coffee 4.5kg

$$\vec{J} = \Delta mv$$

$$= 4.5kg \cdot (0 - 22.1 \text{ m/s})$$

$$= -99.6 \text{ kg m/s}$$

$$\vec{J} = F \cdot \Delta t = \Delta mv$$

$$F = \frac{\Delta mv}{\Delta t} = \frac{-99.6}{0.25} = \underline{498 \text{ N}} \text{ totally breaks.}$$

If empty

$$\vec{J} = 0.5kg(-22.1 \text{ m/s}) = -11.05 \text{ kg m/s}$$

$$F = \frac{-11.05}{0.2} = \underline{55 \text{ N}} \text{ it's ok if empty!}$$