Physics 2101,
FINAL EXAM
Spring 2010

May 11, 2010

Name:____________________________

Section: (Circle one)

1 (Rupnik, MWF 8:40 AM)

2 (Rupnik, MWF 10:40 AM)

3 (Zhang, MWF 12:40 PM)

4 (Plummer, TTh 9:10)

5 (Jin, TTh 12:10)

6 (González, TTh 4:40)

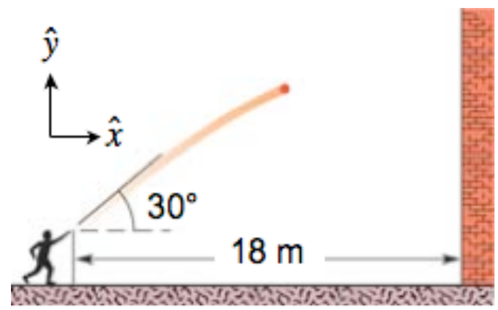
7(Sprunger, TTh 1:40)

- Please be sure to write (print) your name and circle your section above.
- Please turn OFF your cell phone and MP3 player!
- Feel free to detach, use, and keep the formula sheet. No other reference material is allowed during the exam.
- You may use either a scientific or a graphing calculator.
- GOOD LUCK!

THERE IS A TOTAL OF 200 points

SHOW WORK FOR THE NON-MULTIPLE CHOICE PROBLEMS

1. (7 pts) You throw a ball towards a wall at speed $v_0 = 25$ m/s and at an angle θ_0=30.0° above the horizontal. The wall is d=18.0 m from the release point of the ball. What is the vertical component of its velocity as it hits the wall?



A) 4.35 m/s

B) 7.35 m/s

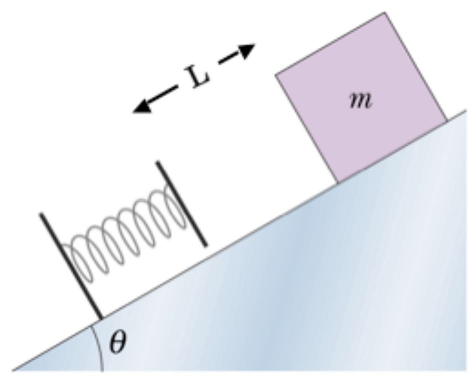
C) 17.94 m/s

D) -4.35 m/s

E) -7.35 m/s

2. A block of mass m and originally at rest slides a distance L down a frictionless incline at angle θ where it runs into a spring with spring constant k. When the block momentarily stops, it compresses the spring by a distance d.

a) (7 pts) What is the distance L from the release to the moment it hits the spring?



A) $\dfrac{kd^2}{2mg\sin\theta} + d$

B) $\dfrac{kd^2}{2mg\sin\theta} - d$

C) $\dfrac{kd^2}{2mg\cos\theta} - d$

D) $\dfrac{kd^2}{4mg\sin\theta} + d$

E) $\dfrac{kd^2}{2mg\cos\theta}$

b) (5 pts) After maximally compressing the spring at the lower left, the block is propelled upwards. Circle the only correct statement about work during the upward motion of the block, until it stops again.

A) Work done by the normal force on the block is $+mg(d+L)\cos\theta$.

B) Work done by the normal force on the block is $-mg(d+L)\cos\theta$.

C) Work done by weight (gravitational force) is $-mg(d+L)\sin\theta$.

D) Work done by weight (gravitational force) is $+mg(d+L)\sin\theta$.

E) Work done by the spring force is zero .

3. Tornado Smith is driving a motorcycle around a loop-de-loop at a constant speed in a vertical circle. The motorcycle speed is $v = 8$ m/s in a vertical circle with a radius of $R = 3$ m.

a) (5 pts) The acceleration, a_c, of the motorcycle at the top of the circle is

A) 2.7 m/s^2 , down

B) 9.8 m/s^2 , down

C) 64.0 m/s^2 , down

D) 21.3 m/s^2 , up

E) 21.3 m/s^2 , down

b) (5 pts) At the top of the circle, the normal force on the motorcycle will be

A) $F_N = mg$

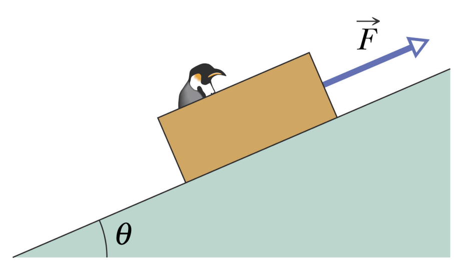
B) $F_N = ma_c$

C) $F_N = ma_c + mg$

D) $F_N = ma_c - mg$

E) None of the above

4. (7 pts) A loaded penguin sled weighing mg rests on a inclined plane as shown in the figure. Between the sled and the plane the coefficient of static friction is μ_s, and the coefficient of kinetic friction is μ_k. What value of F is required to move the block up the plane at constant velocity?



A) $F = mg - \mu_k mg\cos\theta$

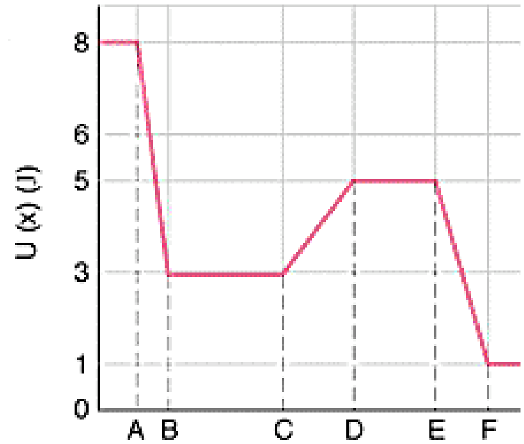
B) $F = mg + \mu_k mg\cos\theta$

C) $F = mg(\sin\theta - \mu_k\cos\theta)$

D) $F = mg(\sin\theta + \mu_k\cos\theta)$

E) $F = mg(\cos\theta + \mu_k\sin\theta)$

5. The figure below gives the potential energy of a particle as a function of position *x*.



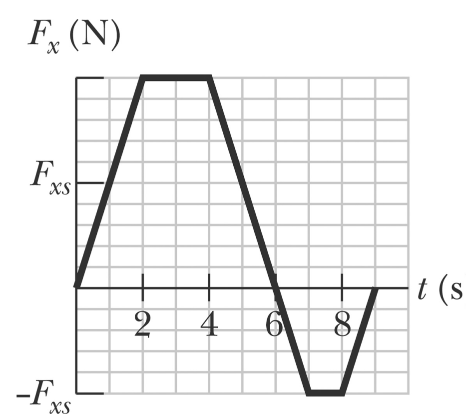
a) (4 pts) What value must the mechanical energy E_{mech} of the particle not exceed if the particle is to be trapped in the potential well at the left-hand side of the figure (~ BC) ? CIRCLE CORRECT ANSWER

1 J **3 J** **5 J** **6 J** **8 J**

b) (4 pts) If the particle has a mechanical energy E_{mech} of 6 J, in which region will the particle have the least speed? CIRCLE CORRECT ANSWER

BC **CD** **DE** **EF**

6. A toy racecar with mass *m* can move along the *x*-axis. The figure below gives F_x of the force acting on the car, which begins at rest at time t = 0. CIRCLE THE CORRECT ANSWER to each of the following questions:



a) (4 pts) At what time is the momentum the largest?

2 s **4s** **6 s** **8 s** **9 s**

b) (5 pts) At t = 9 seconds, the car is…

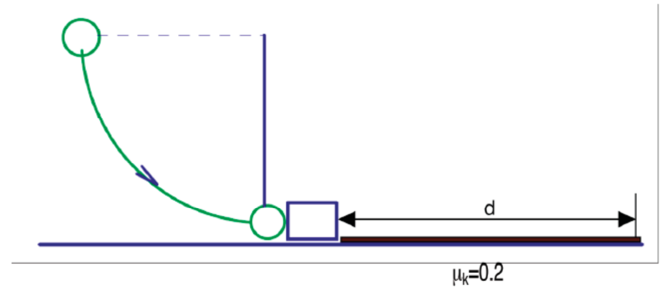
A) moving in the positive *x* direction

B) moving in the negative *x* direction

C) not moving

D) cannot determine from graph

7. A ball of mass 0.5 kg is fastened to a cord that is 0.7 m long and fixed at the far end. The ball is then released when the cord is horizontal. At the bottom of its path, the ball strikes a 2.5 kg block initially at rest on a surface with kinetic friction constant $\mu_k =$ 0.20. The collision is elastic and instantaneous.



→ SHOW WORK FOR CREDIT ←

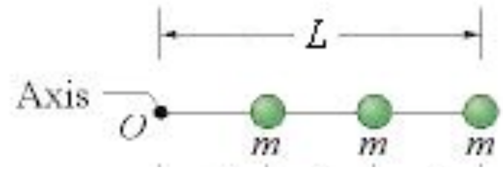
a) (5 pts) What is the speed of the ball right before it collides with the block?

b) (7 pts) What is the speed of the block right after the collision?

c) (7 pts) What is the maximum distance *d* that the block travels after the elastic collision?

8. (5 pts) The figure below shows three particles of mass m that have been glued to a rod of length L and negligible mass. The assembly can rotate around a perpendicular axis through point O at the left end. *The distance between particles and point O is the same.*

What is the total rotational inertia about the point O?



A) $3mL^2$

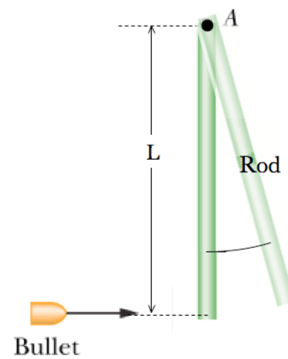
B) $\frac{1}{3}mL^2$

C) $\frac{1}{9}mL^2$

D) $\frac{10}{9}mL^2$

E) $\frac{14}{9}mL^2$

9. (4 pts) As shown in the figure, a sticky bullet is fired towards the bottom end of a uniform steel ROD hanging from a frictionless, but stationary hinge at **A**. After a very short impact, the bullet sticks to the rod.



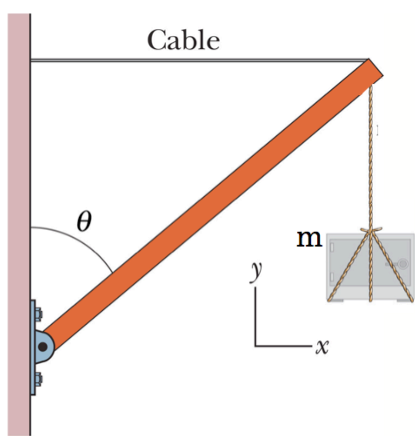
CIRCLE THE CORRECT ANSWER:

During the impact, the **total**:

i) linear momentum remains constant. **ii) angular momentum remains constant.**

iii) mechanical energy remains constant **iv) kinetic energy remains constant**

10. (5 pts) A massless beam of length $L = 10$ m used to hang a load of mass $m = 8$ kg. It is suspended by a horizontal cable and a hinge. The beam is at an angle $\theta = 50°$ relative to the vertical wall. What is the tension in the cable?



A) 65.8 N
B) 93.4 N
C) 60.1 N
D) 78.4 N
E) 39.2 N

11. In the figure below, three spheres of mass M are located at distances $d_1 = 0.300$ m and $d_2 = 0.400$ m.

a) (6 pts) In terms of G (Newton's constant) and M, what is the magnitude of the net gravitational force on sphere B due to spheres A and C?

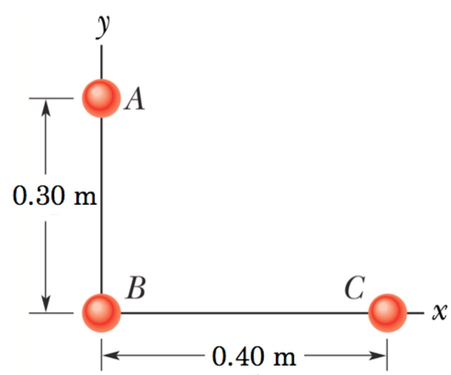
A) 5.83 GM^2

B) 17.3 GM^2

C) - 5.83 GM^2

D) 12.7 GM^2

E) 4.23 GM^2



b) (6 pts) In terms of G, how much work is done by the gravitational force to set ALL of the masses in this configuration, bringing them from an infinite distance.

A) 7.83 GM^2

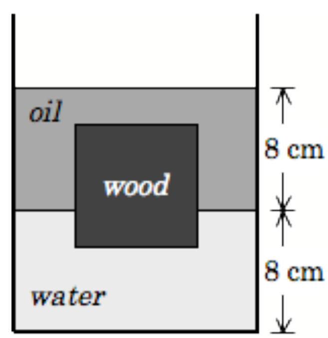
B) 17.3 GM^2

C) - 7.83 GM^2

D) 12.7 GM^2

E) 4.23 GM^2

12. (6 pts) A cubical block of wood, 8.0 cm on a side, floats at the interface between oil on top and water below, with its lower surface 3.5 cm below the interface (see the cross section view in the figure). The density of the oil is 790 kg/m^3 and the water is 1000 kg/m^3 What is the buoyant force on the block?



A) 3.96 N

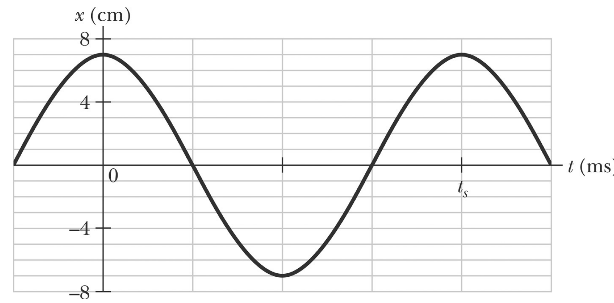
B) 5.02 N

C) 4.42 N

D) 4.56 N

E) 5.65 N

13. The figure gives the position (in cm) as function of time of a 0.050 kg block in simple harmonic motion on the end of a spring. The period of the oscillation is 20 ms. → *SHOW WORK FOR CREDIT* ←



a) (5 pts) What is the spring constant?

b) (5 points) What is the magnitude of the maximum velocity?

c) (5 pts) What is the magnitude of the maximum force?

14. A string fixed at both ends is 8.4 m long and has a mass of 0.12 kg. It is subjected to a tension of 90 N and set into oscillation.

a) (5 pts) What is the speed of the waves on the string?

A) 79.4 m/s
B) 27.4 m/s
C) 9.5 m/s
D) 70 m/s
E) 53.6 m/s

b) (5pts) What is the longest possible wavelength for a standing wave?

A) 2.1 m
B) 4.2 m
C) 8.4 m
D) 16.8 m
E) 33.6 m

c) (4 pts) What is the frequency of that wave?

A) 9.4 Hz
B) 4.7 Hz
C) 1.6 Hz
D) 8.3 Hz
E) 2.4 Hz

15. In order to cool down 300g of soda one places the liquid, initially at 10^0C , inside of an insulated container together with 200g of ice that is initially at 0^0C. Use specific heat of the soda = 4187 J/ kg·K.

→ SHOW WORK FOR CREDIT ←

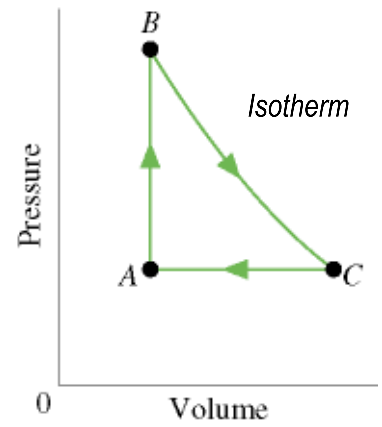
a) (7 pts) What's the final temperature of the system?

b) (7 pts) How much mass of ice melts?

c) (7 pts) What is the change in *entropy* of the ice that undergoes a phase change?

16. A sample of a monatomic ideal gas is taken through the cycle shown. The volumes are given by $V_A = V_B = 3\ m^3$ and $V_C = 7\ m^3$. The pressure at point C is $P_C = 100{,}000$ Pa and the temperature is $T_C = 300$ K. The process from A→B is at constant volume (isochoric), from B→C is at constant temperature (isothermal), and C→A is at constant pressure (isobaric).

→ SHOW WORK FOR CREDIT ←



a) (5 pts) How many moles are in the gas?

b) (7 pts) What is the total work done by the gas during the cycle?

c) (3 pts) What is the change in the internal energy (E_{int}) of the gas during a <u>cycle</u>?

d) (4 pts) What is the total heat transferred to or from the gas during a <u>cycle</u>?

c) (7 pts) What is the entropy change of the gas during isothermal process B→C ?

17. The energy input (heat input, Q_H) of a Carnot engine is 3 times greater than the work, W, it performs. Circle correct answer for EACH question.

(a) (5 pts) What is its thermal efficiency?

(a) 3. (b) 1. (c) 0.3333 (d) impossible to determine.

(b) (5 pts) For this engine, what fraction of the energy input is expelled to the cold reservoir, Q_L/Q_H?

(a) 0.333 (b) 0.667 (c) 1. (d) impossible to determine

(c) (5 pts) If the temperature of the hot reservoir in this engine is 600K, the cold reservoir is at

(a) 200K (b) 300K (c) 400K (d) impossible to determine

(d) (5 pts) The total entropy change during a complete cycle of the working gas in this Carnot engine is …

(a) positive (b) zero (c) negative (d) impossible to determine.