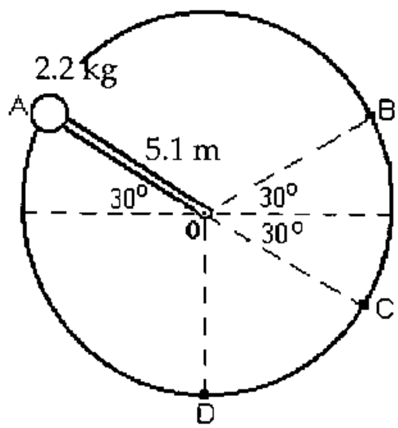
Physics 2A, Sec C00: Mechanics -- Winter 2011 Instructor: B. Grinstein

Mid Term #2 SOLUTIONS

INSTRUCTIONS: Use a pencil #2 to fill your scantron. Write your code number and bubble it in under "EXAM NUMBER;" an entry in error will result in an automatic 10% deduction. Bubble in the quiz form (see letter A--D at bottom of page) in your scantron under "TEST FORM;" an error entering the "test form" will result in automatic 20% deductions, and may lead to disqualification. Write your name and 3-digit ID at the bottom of this page and turn it in with your scantron when you are finished working on the exam.

1)

Figure 7.1a



A 5.1 m massless rod is loosely pinned to a frictionless pivot at O. A 2.2 kg ball is attached to the other end of the rod. The ball is held at A, where the rod makes a 30° angle above the horizontal, and is released. The ball-rod assembly then swings freely in a vertical circle between A and B. The ball passes through C, where the rod makes an angle of 30° below the horizontal. The speed of the ball as it passes through C is closest to:

A) 9.0 m/s B) 13.1 m/s C) 7.9 m/s D) 11.3 m/s E) 10.0 m/s

From conservation of energy (take $U=0$ at O)

$$E_A = E_C$$

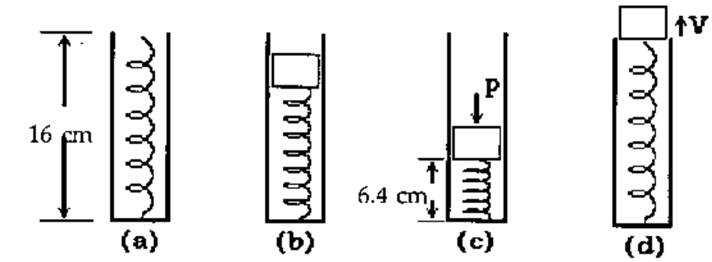
$$\frac{1}{2}\cancel{m}\cancel{v_A^2}^{\,0} + mgl\sin 30^\circ = \frac{1}{2}\cancel{m}v_B^2 - mgl\sin 30^\circ$$

$$\cancel{\frac{1}{2}}v_B^2 = 2gl\cancel{\sin 30^\circ}$$

$$v_B = \sqrt{2gl} = \sqrt{2\times 9.8\times 5.1} \simeq 10.0 \text{ m/s}$$

Name____________________ Student 3-digit ID_______

2)



The force constant of a spring is 400 N/m and its unstretched length is 16 cm. The spring is placed inside a smooth tube that is 16 cm tall (Figure a). A 0.56 kg disk is lowered onto the spring (Figure b). An external force P pushes the disk down further, until the spring is 6.4 cm long (Figure c). The external force is removed, the disk is projected upward and it emerges from the tube (Figure d).
The velocity V of the disk as it emerges from the tube in Figure d is closest to:

A) 430 m/s B) 1.3 m/s C) 2.9 m/s D) 260 m/s E) 2.2 m/s

take gravitational potential energy $U_g = 0$ at the bottom.

$$E_c = E_d$$

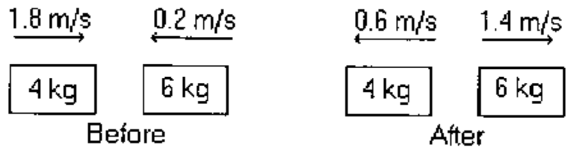
$$\frac{1}{2} m \cancel{v_c^2}^{\,0} + U_g(6.4\,cm) + U_s(6.4\,cm) = \frac{1}{2} m v_D^2 + U_g(16\,cm) + U_s(16\,cm)$$

$$mg \times 6.4 \times 10^{-2} + \frac{1}{2} k \frac{(16-6.4)^2}{(100)^2} = \frac{1}{2} m v^2 + mg \times 16 \times 10^{-2}$$

$$v^2 = 2g(6.4-16)\times 10^{-2} + \frac{k}{m} \times \frac{(16-6.4)^2}{10^4}$$

$$v = \sqrt{-2 \times 9.8 \times 9.6 \times 10^{-2} + \frac{400}{0.56} \times \frac{(9.6)^2}{10^4}}$$

$$\simeq 2.16 \text{ m/s}$$



3) Determine the character of the collision in the figure above. The masses of the blocks, and the velocities before and after are given. The collision is:

A) partially inelastic

B) characterized by an increase in kinetic energy

C) completely inelastic

D) perfectly elastic

E) not possible because momentum is not conserved.

$$P_i = 4\times 1.8 - 6\times 0.2 = 6 \text{ kg m/s}$$

$$P_f = -0.6\times 4 + 1.4\times 6 = 6 \text{ kg m/s}$$

$\Rightarrow$ momentum is conserved.

$$KE_i = \frac{1}{2}\times 4\times 1.8^2 + \frac{1}{2}\times 6\times 0.2^2 = 6.6 \text{ J}$$

$$KE_f = \frac{1}{2}\times 4\times 0.6^2 + \frac{1}{2}\times 6\times 1.4^2 = 6.6 \text{ J}$$

since energy is conserved, the collision is perfectly elastic.

4) A girl throws a stone from a bridge. Consider the following ways she might throw the stone. The speed of the stone as it leaves her hand is the same in each case.

Case A: Thrown straight up.

Case B: Thrown straight down.

Case C: Thrown out at an angle of 45° above horizontal.

Case D: Thrown straight out horizontally.

In which case will the speed of the stone be greatest when it hits the water below?

A) Case D

B) Case B

C) Case C

D) Case A

E) The speed will be the same in all cases.

let U_g be the gravitational potential energy

take $U_g = 0$ at the surface of water.

on the bridge

$$E_i = \frac{1}{2} m v_i^2 + \underbrace{U_g}_{mgH}$$

at the surface of water

$$E_f = \frac{1}{2} m v_f^2$$

since U_g & v_i^2 are the same for all four cases, v_f^2 is the same as well.

5) A sand mover at a quarry lifts 2,000 kg of sand per minute a vertical distance of 12 meters. The sand is initially at rest and is discharged at the top of the sand mover with speed 5 m/s into a loading chute. At what minimum rate must power be supplied to this machine?

A) 6.65 kW B) 4.34 kW C) 524 W D) 1.13 kW E) 3.92 kW

We will compute the change in energy of the sand lifted during 1 second.

$$\Delta U = mgh = 2000 \times \frac{1}{\cancel{60}} \times 9.8 \times \cancel{12}^{2}$$

$$= 400 \times 9.8 \ \text{J}$$

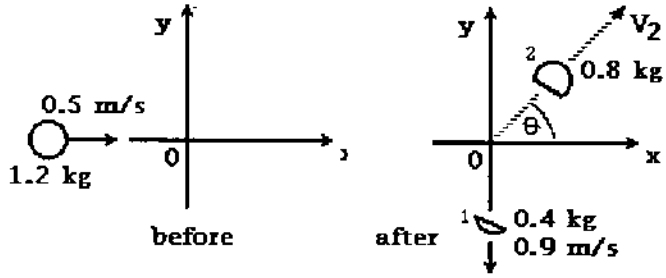
$$\Delta K = \frac{1}{2} m v^2 = \frac{1}{\cancel{2}} \times \overset{1000}{\cancel{2000}} \times \frac{1}{\cancel{60}} \times 5^2$$

$$= \frac{2500}{6} \ \text{J}$$

thus $\Delta E = 400 \times 9.8 + \frac{2500}{6} \simeq 4.34 \times 10^3 \ \text{J}$

from work-energy theorem, we conclude that

$$P = 4.34 \ \text{kW}.$$



6) A 1.2 kg spring-activated toy bomb slides on a smooth surface along the x-axis with a speed of 0.50 m/s. At the origin 0, the bomb explodes into two fragments. Fragment 1 has a mass of 0.4 kg and a speed of 0.9 m/s along the negative y-axis. The angle θ, made by the velocity vector of fragment 2 and the x-axis, is closest to:

A) 31° B) 59° C) 38° D) 53° E) 37°

we have the initial momentum (before explosion)

$$P_{x_i} = 1.2 \times 0.5 = 0.6 \text{ kg m/s}$$

$$P_{y_i} = 0$$

the final momentum (after explosion)

$$P_{x_f} = m_2 v_2 \cos\theta = 0.8 \times v_2 \cos\theta$$

$$P_{y_f} = m_2 v_2 \sin\theta - m_1 v_1$$

$$= 0.8 v_2 \sin\theta - 0.36 \text{ kg m/s}$$

from conservation of momentum

$$0.8\, v_2 \cos\theta = 0.6 \text{ kg m/s} \quad \text{— (1)}$$

$$0.8\, v_2 \sin\theta = 0.36 \text{ kg m/s} \quad \text{— (2)}$$

$$(2)/(1) \Rightarrow \tan\theta = \frac{0.36}{0.6} = \frac{6}{10}$$

$$\theta = \tan^{-1} 6/10 \simeq 31°$$

7) Consider two less-than-desirable options. In the first you are driving 30 mph and crash head-on into an identical car also going 30 mph. In the second option you are driving 30 mph and crash head-on into a stationary brick wall. In neither case does your car bounce off the thing it hits, and the collision time is the same in both cases. Which of these two situations would result in the greatest impact force?

A) Hitting the other car.

B) Hitting the brick wall.

C) The force would be the same in both cases.

D) We cannot answer this question without more information.

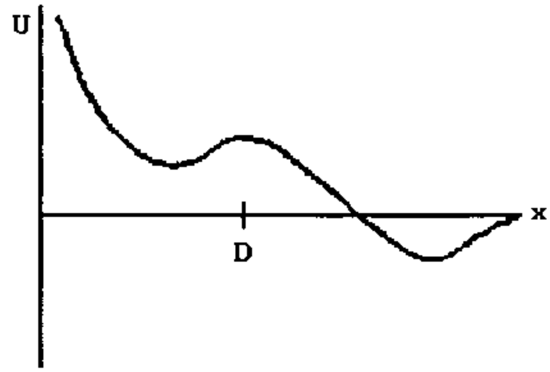
E) None of these is true.

recall $F_{avg} \cdot \Delta t = \Delta p$

since your car doesn't bounce off

$\Delta p = 0 - mv = -mv$ in both cases.

so the force would be the same.



8) The figure above shows a graph of potential energy versus position for a particle moving in a straight line. From this curve, for the region shown, we deduce that

A) the force on the particle would be strongest when the particle is near the origin.

B) this could not represent an actual physical situation, since the drawing shows the potential energy going negative, which is not physically realizable. can be shifted by arbitrary constant.

C) the force on the particle would be greatest when the particle is near point D. equilibrium

D) for a given value of x, the particle can have a total energy that lies either above or below the value given by the curve at that point.

E) there are three positions of stable equilibrium. only two

from $F = -\frac{dU}{dx}$

so the force will be strongest when the slope is steepest.

the equilibrium is at $\left.\frac{dU}{dx}\right|_{x_e} = 0$

stable equilibrium when $\left.\frac{d^2U}{dx^2}\right|_{x_e} \geq 0$

D) is incorrect because $E_T = U + K$ and $K \geq 0$

so $E \geq U$.

9) In order to do work on an object,

A) the object must move.

B) the force doing the work must be directed perpendicular to the motion of the object.

C) it is necessary that friction not be present.

D) the applied force must be greater than the reaction force of the object.

E) it is necessary that friction be present.

recall $dW = \vec{F} \cdot d\vec{x}$

thus need $d\vec{x} \neq 0 \Rightarrow$ object must move

10) A student designs a clock using a mass and a spring. Each oscillation of the mass advances the clock by one second. When the student builds the clock, he discovers he erred and each oscillation takes two seconds. What change can he make to fix the clock?

A) quadruple the spring constant of the spring

B) double the spring constant of the spring

C) double the amplitude of the oscillations

D) quadruple the mass

E) double the mass

from $\omega = \sqrt{\frac{k}{m}}$ and $T = \frac{2\pi}{\omega}$

to decease T by $\frac{1}{2}$, must increase ω by 2.

this can be achieved by making $\frac{k}{m}$ becomes quadruple.