PHYS 2101 — Test II

Monday, 14. Nov. 2005 — 5:15 – 6:45 p.m.

ID No:	
NAME:	
SECTION:	

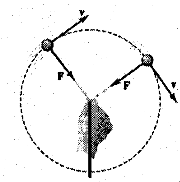
1-10	11-13	14-16	17	Total

Full Mark: 50 points | **Please check that your examination paper has 6 pages!**

Please use the following: $g = 10\ ms^{-2}$ $\sin 37° = \cos 53° = 0.6$ $\sin 53° = \cos 37° = 0.8$

Circle the correct answer in each part of the following 10 questions. (15 points)

1. **You swing a ball at the end of string in a vertical circle. Since the ball is in circular motion there has to be a centripetal force. At the bottom of the ball's path, what is F_R equal to?**



   a) $F_R = T + mg$
   b) $F_R = T - mg$
   c) $F_R = T$
   d) $F_R = mg$

2. **A coin of mass m rests on a turntable a distance r from the axis of rotation. The turntable rotates with a frequency of f. What is the minimum coefficient of static friction between the turntable and the coin if the coin is not to slip?**

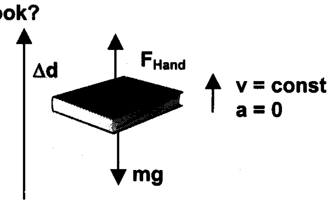
   a) $(4\pi^2 f r^2)/g$
   b) $(4\pi^2 f^2 r)/g$
   c) $(4\pi f^2 r)/g$
   d) $(4\pi f r^2)/g$

3. **A stone, of mass m, is attached to a strong string and turned in a vertical circle of radius r. At the exact top of the path the tension in the string is 3 times the stone's weight. The stone's speed at this point is given by**

   a) $\sqrt{gr}$
   b) $\sqrt{3gr}$
   c) $2\sqrt{gr}$
   d) 2gr.

4. **You lift a book with your hand in such a way that it moves up at constant speed. While it is moving, what is the total work done on the book?**

   a) Zero
   b) $F_{HAND} \times \Delta d$
   c) $(F_{HAND} + mg) \times \Delta d$
   d) $mg \times \Delta d$



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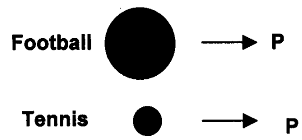
(1.5) **5. A mass attached to a vertical spring causes the spring to stretch and the mass to move downwards. What can you say about the spring's potential energy (PE_s) and the gravitational potential energy (PE_g) of the mass?**

a) both PE_s and PE_g decrease
b) PE_s decreases and PE_g increases
c) both PE_s and PE_g increase
d) PE_s increases and PE_g decreases
e) PE_s increases and PE_g is constant

(1.5) **6. A football and a tennis ball are rolling toward you with the same momentum P as shown in the figure. If you exert the same force to stop each one, which takes a longer time to bring to rest?**



a) the football
b) the tennis ball
c) same time for both
d) impossible to say

(1.5) **7. When you pay the electric company by the kilowatt-hour, what are you actually paying for?**

a) power
b) energy
c) current
d) none of the above

(1.5) **8. A system of particles is known to have a total kinetic energy of zero. What can you say about the total momentum of the system?**

a) momentum of the system is zero
b) momentum of the system is negative
c) momentum of the system is positive
d) you cannot say anything about the momentum of the system

(1.5) **9. In an elastic collision, if the momentum is conserved, then which of the following statements is true about kinetic energy?**

a) Kinetic energy is lost.
b) Kinetic energy is gained.
c) Kinetic energy is also conserved.
d) none of the above

(1.5) **10. When a bullet is fired from a gun, the bullet and the gun have equal and opposite momenta. If this is true, then why is the bullet deadly? (whereas it is safe to hold the gun while it is fired)**

a) it is much sharper than the gun
b) it is smaller and can penetrate your body
c) it goes a longer distance and gains speed
d) it has more kinetic energy than the gun

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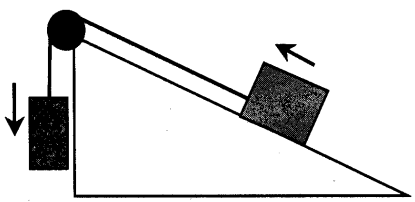
11. A box is being pulled up a rough incline by a rope connected to a pulley as shown in the figure. (6 points)

a) Which force(s) are doing work on the box?
b) Which force(s) are not doing work on the box?
c) Which forces are doing positive work and which force(s) are doing negative work on the Box?



(3) (a) Tension (1), friction (1) and weight (1)

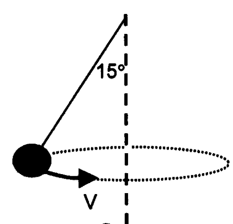
(1) (b) Normal force

(2) (c) Positive work : Tension force (1)

Negative work : Friction (0.5) and weight (0.5)

12. In the figure shown, a ball is tied to a pole by a 24 cm long string which makes an angle of 15° with the vertical. If the ball is allowed to rotate with speed V, (5 points)

a) In what direction does the net force on the ball point?
b) Calculate the speed of the ball.



(1) (a) Along the horizontal component of the tension force

(4) (b) $T\cos 15° = mg$ (1), $T\sin 15° = m\frac{v^2}{r}$ (1) and $r = 24\sin 15 = 0.062\,m$ (1)

$\tan 15° = \frac{v^2}{rg} = \frac{v^2}{0.062 \times 10}$ (1) $\Rightarrow v = 0.4\,ms^{-1}$

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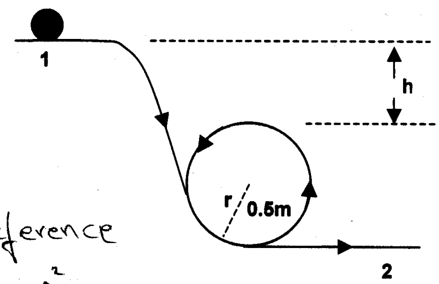
13. A ball of mass m slides from position 1 without friction along the looped track shown in the figure. If the ball is to remain on the track, even at the top of the circle (whose radius is r =0.5m), (5 points)

(2.5)

a) From what minimum height h must the ball be released?
b) What is the speed of the ball at position 2?



(a) For minimum height at the top of the circular path

$N = 0 \qquad N + mg = m\frac{v_{min}^2}{r}$

$\Rightarrow v_{min} = \sqrt{gr}$

Take the top of circular path as reference

$E_i = E_f \Rightarrow mgh = \frac{1}{2} m v_{min}^2$

$\Rightarrow h = \frac{v_{min}^2}{2g} = \frac{r}{2} = \frac{0.5}{2} = 0.25\,m$

(2.5) (b) At position 1 $E_i = mgh$

At position 2 $E_f = \frac{1}{2} m v_2^2 - 2mgr$

$E_i = E_f \quad mgh = \frac{1}{2} m v_2^2 - 2mgr \Rightarrow v_2^2 = 2g(h + 2r)$

Since $h = r/2 \quad \therefore v_2^2 = 2g(r/2 + 2r) = 5gr$

$\therefore v_2 = \sqrt{5gr} = \sqrt{5(10)0.5} = 5\,ms^{-1}$

(1.5) **14. State the work-energy principle.** (1.5 points)

The net work done on an object is equal to the change in the object's kinetic energy ($W_{net} = \Delta K.E$)

15. State the principle of conservation of mechanical energy for conservative forces. (1.5 points)

If only conservative forces are acting, the total (1.5) mechanical energy of a system neither increases nor decreases in any process. It stays constant – It is conserved

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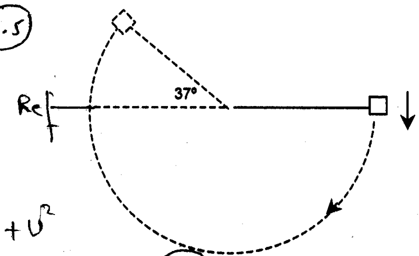
16. A 2 kg block tied to the end of a 1.5 m long string is given an initial velocity of 6 m s⁻¹ when it is in the horizontal position. (6 points)

a) What is the tension in the string when the string makes an angle of 37° with the horizontal as shown in the figure?

b) What is the maximum tension in the string during the motion?



(3) (a) $E_i = \frac{1}{2} m v^2 = \frac{1}{2}(2)(6)^2 = 36\ J \rightarrow (0.5)$

$E_f = mgh + \frac{1}{2} m v^2 \rightarrow (1)$

$= mg(1.5 \sin 37) + \frac{1}{2} m v^2$

$E_i = E_f \quad 36 = 20(1.5 \times 0.6) + v^2$

$36 = 18 + v^2 \Rightarrow v^2 = 18 \rightarrow (0.5)$

but $T + mg \sin 37 = \frac{m v^2}{r} \Rightarrow T + 20(0.6) = 2\frac{18}{15} \quad (1)$

$\Rightarrow T = 12\ N$

(3) (b) The maximum tension is found when the block is at the bottom of the circular path.

$T - mg = \frac{m v^2_{bottom}}{r} \rightarrow (1)$

$(0.5) \leftarrow E_i = 36\ J \quad E_{bottom} = -mgh + \frac{1}{2} m v^2_{bottom} \rightarrow$ (1 mark)

$= -20(1.5) + v^2_{bottom}$

$E_i = E_{f\,bottom} \Rightarrow 36 = -20(1.5) + v^2_{bottom}$

Substitute : (2) in (1) $\quad \therefore v^2_{bottom} = 66 \rightarrow (2)$ (0.5 mark)

$T - 20 = 2\frac{66}{1.5} \Rightarrow T = 108\ N$

(1 mark)

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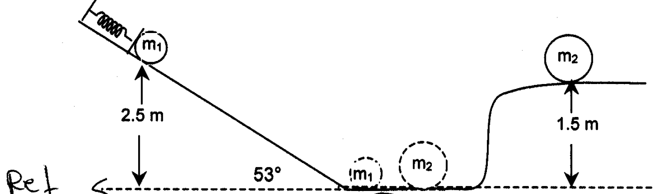
17. a) A ball of mass m_1 = 2 kg is at a height of 2.5 m on 53° inclined plane. The coefficient of friction on the 53° inclined plane is 0.5. In this position, m_1 is compressing a spring by 0.4 m, but is not tied to the spring. The spring constant is 175 N m^{-1}. When m_1 is released, it moves down the plane. Find the speed of m_1 when it reaches the bottom.

b) A second ball of mass m_2 = 4 kg is released from a height of 1.5 m as shown in the figure. The two balls collide elastically on the frictionless horizontal plane. Find the velocity of m_1 and m_2 after the collision.

(10 points)



(4) (a) For m_1: $E_i = \frac{1}{2}kx^2 + mgh = \frac{1}{2}(175)(0.4)^2 + 20(2.5) = 14 + 50 = 64$ J (0.5) (0.5)

$E_f = \frac{1}{2}m_1 v_{1f}^2 = v_{1f}^2 \rightarrow$ (0.5)

work done by friction $= -\mu N d = -0.5\,(m_1 g \cos 53)\left(\frac{2.5}{\sin 53}\right)$ (1.5)

$= -18.75$ J

$W_{nc} = \Delta E = E_f - E_i \Rightarrow -18.75 = v_{1f}^2 - 64$

$v_{1f} = \sqrt{45.3} = 6.7\ ms^{-1} \rightarrow$ (1)

(6) (b) For m_2: $E_i = mgh = 40(1.5) = 60$ J $\rightarrow$ (1)

$E_f = \frac{1}{2}m_2 v_{2f}^2$, $E_i = E_f \Rightarrow 60 = 2v_{2f}^2 \Rightarrow v_{2f} = \sqrt{30} = 5.5\ ms^{-1}$ (1)

(2) $P_i = P_f$ (m1 → 6.7 ms^{-1}, m2 ← 5.5 ms^{-1}, → x)

$m_1 v_1 - m_2 v_2 = m_1 v_1' + m v_2' \Rightarrow 2(6.7) - 4(5.5) = 2v_1' + 4v_2'$

For elastic (head on collision) $\boxed{-8.6 = 2v_1' + 4v_2'}$ Eq (1)

(2) $v_1 - v_2 = -(v_1' - v_2')$

$6.7 - (-5.5) = v_2' - v_1' \rightarrow 12.2 = v_2' - v_1' \rightarrow \boxed{v_2' = 12.2 + v_1'}$ Eq (2)

Sub. Eq (2) in Eq (1)

$-8.6 = 2v_1' + 4(12.2 + v_1') \rightarrow v_1' = -9.6\ ms^{-1}$

and $v_2' = 12.2 - 9.6 = 2.6\ ms^{-1}$

The End