Solutions

Physics 2414
Midterm #3 – Fall 2012

Version A

Multiple choice (6 points each)

1) The weight of an object on the moon is one-sixth of its weight on Earth. The ratio of the kinetic energy (KE) of a body on Earth moving with speed V to that of the same body moving with speed V on the moon is KE_{earth}/KE_{moon}=

a. 6
b. 36
(c.) 1
d. 1/6
e. 1/36

Kinetic Energy depends on mass not weight
mass same on Earth and moon

2) A 5.0 kg cart is moving horizontally at 6.0 m/s. In order to change its speed to 10.0 m/s, the net work done on the cart must be:

a. 40 J
b. 90 J
(c) 160 J
d. 320 J
e. 550 J

$W_{net} = \Delta K = K_f - K_i$
$= \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$
$= \frac{1}{2} m (v_f^2 - v_i^2) = \frac{1}{2} \cdot 5kg\,(10 m/s^2 - 6 m/s^2) = 160 J$

3) An elevator is rising at constant speed. Consider the following statements:

I. The upward cable force is constant. T
II. The kinetic energy of the elevator is constant. T
III. The gravitational potential energy of the elevator is constant. F
IV. The acceleration of the elevator is zero. T
V. The mechanical energy of the elevator is a constant. F

a. All five are true
b. Only II and V are true
c. Only IV and V are true
d. Only I,II and III are true
(e.) Only I,II, and IV are true

4) A cart is gliding with velocity v on a level frictionless track. Suppose it then encounters a frictionless hill. The cart climbs to a height h before stopping and turning around. For the cart to only climb half the height, what initial velocity will it need?

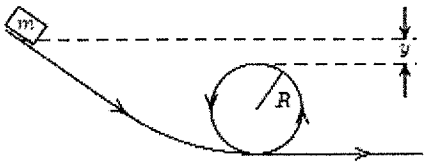
a. v/4
b. v/2
(c.) v/√2
d. v
e. Impossible to tell without knowing the mass of the cart

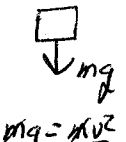
$\frac{1}{2} m v^2 = mgh$ $\quad v^2 = 2gh$ $\quad v_2^2 = 2g\frac{h}{2}$ $\quad \frac{v^2}{v_2^2} = \frac{2gh}{gh}$ $\quad v_2^2 = \frac{v^2}{2}$ $\quad v_2 = \frac{v}{\sqrt{2}}$

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

$mgh = \frac{1}{2}mgr$

$h = \frac{r}{2}$





$mg = \frac{mv^2}{r}$

$v^2 = gr$

5) A small object of mass m starts from rest as the position shown and slides along the frictionless loop-the-loop track of radius R. What is the smallest value of y such that the object will slide without losing contact with the track?
   a. R/4
   (b) R/2
   c. R
   d. 2R
   e. 2.5R

6) Two unequal masses are connected by a massless string over a frictionless pulley. Which of the following statements is true about the total gravitational potential energy and the total kinetic energy of the 2 blocks after they are released from rest?
   a. Potential energy increases, Kinetic energy increases
   (b) Potential energy decreases, Kinetic energy increases
   c. Potential energy constant, Kinetic energy constant
   d. Potential energy constant, Kinetic energy increases
   e. Potential energy decreases, Kinetic energy decreases

K=0 since not moving
K>0 after moving
larger mass goes down
smaller mass goes up
since potential E = mgh
potential E decreases

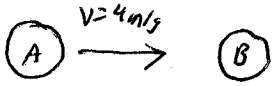
7) Two balls having different masses reach the same height when shot into the air from the ground. Assuming no air resistance, which statement is true:
   (a) Both balls left the ground with the same speed
   b. Both balls left the ground with the same kinetic energy
   c. Both balls will have the same potential energy at the highest point
   d. The heavier ball must have left the ground with a greater speed than the lighter ball
   e. Both balls have no acceleration at their highest point

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

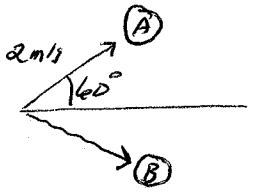
$v^2 = gh$

independent of mass
same h
same v

8) Two pucks collide on a frictionless air-hockey table. The pucks have equal masses m=0.20 kg. Puck A has an initial velocity of 4.0 m/s in the positive x direction and a final velocity of 2.0 m/s at an angle of 60° to the +x axis. Puck B is initially at rest. What is the speed of puck B?
   a. 1.73 m/s
   b. 3.0 m/s
   (c.) 3.5 m/s
   d. 4.2 m/s
   e. 4.5 m/s



$m_A = m_B$



$P_{ix} = m_A 4m/s + 0 = m_A \cdot 2m/s \cos 60° + m_B v_x = P_{fx}$

$P_{iy} = 0 + 0 = m_A 2m/s \sin 60° + m_B v_y = P_{fy}$

x: $v_x = 4m/s - 2m/s \cos 60° = \underline{3m/s}$

y: $v_y = \underline{-1.73m/s}$

$v = \sqrt{v_x^2 + v_y^2} = \sqrt{(3m/s)^2 + (-1.73m/s)^2} = \underline{3.5m/s}$

9) A rifle bullet with mass 8.00 g strikes and embeds itself in a block with mass 0.992 kg that rests on a frictionless horizontal surface and is attached to a spring. The impact compresses the spring 15.0 cm. From experiment we know that a force of 0.750 N compresses the spring 0.250 cm. What is the initial speed of the bullet?

a. 325 m/s
b. 115 m/s
c. 844 m/s
d. 226 m/s
e. 412 m/s

conserve momentum $.008 v_i = (.008 + .992)\text{kg}\, v_f \Rightarrow v_f = .008 v_i$

conserve K.E $\frac{1}{2}(1\text{kg}) v_f^2 = \frac{1}{2} k x^2$ $F = kx$ $k = \frac{.750\text{ N}}{.00025\text{ m}}$

$k = 300\text{ N/m}$

$v_f^2 = \frac{2}{2}(300\text{N/m})(.15\text{m})^2$ $v_f = 2.59\text{ m/s}$

$v_i = \frac{2.59\text{ m/s}}{.008} = 325\text{ m/s}$

10) A stone is launched at an angle θ above the horizontal. Ignoring air resistance, what fraction of its initial kinetic energy does the projectile have at the top of the trajectory?

a. Cos θ
b. ½
c. Sin θ
d. $\text{Cos}^2\,\theta$
e. $\text{Sin}^2\,\theta$

$K.E_i = \frac{1}{2} m v^2$ v has both x and y components

at top velocity only in x-direction

$KE = \frac{1}{2} m v_x^2 = \frac{1}{2} m (v\cos\theta)^2$

$\frac{\frac{1}{2} m v^2 \cos^2\theta}{\frac{1}{2} m v^2} = \cos^2\theta$

11) A superhero (m=80kg) stands on a ledge 5.0 m above the ground. He grabs a rope attached to a chandelier on the ceiling and swings down and grabs a super villain (m=70.0 kg) who is standing directly under the chandelier. The two people hold on to one another and start to slide across the floor together. If the coefficient of kinetic friction between the floor and their bodies is 0.25, how far do they slide?

a. 4.7 m
b. 3.2 m
c. 5.7 m
d. 4.4 m
e. 6.4 m

Conserve Energy

$mgh = \frac{1}{2} m v^2$

$v = \sqrt{2gh}$

$v = \sqrt{2 \cdot 9.8\text{m/s}^2 \cdot 5\text{m}}$

$v = 9.9\text{ m/s}$

conserve momentum

$80\text{kg} \cdot 9.9\text{m/s} = 150\text{kg}\, v_f$

$v_f = 5.28\text{ m/s}$

$F_f d = \Delta k$

$\mu_k m g d = \frac{1}{2} m v^2$ $d = \frac{v^2}{2\mu_k g} = \frac{(5.28\text{m/s})^2}{2 \cdot .25 \cdot 9.8\text{m/s}^2} = 5.7\text{m}$

12) A heavy and a light marble are released from rest from the same height. Which marble has the greatest momentum right before it lands?

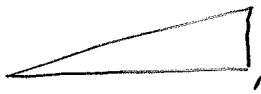
a. The heavy one
b. The light one
c. They have the same final momentum
d. Impossible to determine

same velocity when they hit

larger momentum if larger mass

13) A bicycle and its rider together has a mass of 75 kg. What power output of the rider is required to maintain a constant speed of 4 m/s up a road that rises 5.0 m for every 100 m along the pavement?

a. 147 W
b. 33.8 W
c. 334 W
d. 80 W
e. 103 W



$P = \frac{F_{\parallel} d \cos\theta}{dt}$

$P = \frac{mg\,5m}{t}$

$t = \frac{100\,m}{4\,m/s} = 25\,s$

$P = \frac{(75\,kg)(9.8\,m/s^2)(5\,m)}{25\,s} = 147\,W$

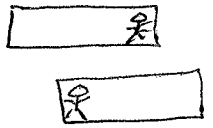
14) Sphere X, of mass 2 kg, is moving to the right at 10 m/s. Sphere Y, of mass 4 kg, is moving to the left at 10 m/s. The two spheres collide head on. The magnitude of the impulse of X on Y is:

a. Twice the magnitude of the impulse of Y on X
b. Half the magnitude of the impulse of Y on X
c. One-fourth the magnitude of the impulse of Y on X
d. Four times the magnitude of the impulse of Y on X
e. The same as the magnitude of the impulse of Y on X

any collision change in momentum same impulse is change in momentum

15) A man sits in the back of a stationary canoe in still water. He then moves to the front of the canoe and sits there. After he moves, the canoe:

a. Is forward of its original position and moving forward
b. Is forward of its original position and moving backward
c. Is rearward of its original position and moving forward
d. Is rearward of its original position and moving backward
e. Is rearward of its original position and not moving



center of mass cannot move

16) A 0.2 kg ball is dropped from a window. It strikes the sidewalk at 30 m/s and rebounds up at 20 m/s. The ball is in contact with the sidewalk for 0.1 seconds. The change in the momentum of the ball is:

a. 20 kg-m/s upward
b. 2 kg-m/s upward
c. 100 kg-m/s upward
d. 10 kg-m/s upward
e. 40 kg-m/s upward

$\Delta p = mv_f - mv_i$

$= .2\,kg(30\,m/s - (-20\,m/s))$

$= .2\,kg(50\,m/s) = 10\,kg\text{-}m/s$