Solutions

Physics 2414
Midterm #3 – Spring 2013

Version A

Multiple choice (6 points each)

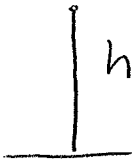
1) A space vehicle of mass M has speed v. At some instant, it separates into two pieces, each of mass M/2. One of the pieces is at rest after the separation. What is the kinetic energy of the moving piece just after the separation?
   a. ¼ Mv^2
   b. ½ Mv^2
   c. Mv^2
   d. $2Mv^2$
   e. $4Mv^2$

Conserve momentum $MV = \frac{M}{2}v_{f_1} + \frac{M}{2}v_{f_2}$ ($v_{f_2} = 0$) $\quad v_{f_1} = 2V$

$$K.E = \frac{1}{2}\left(\frac{M}{2}\right)(2V)^2 = MV^2$$

2) The total mechanical energy of a system
   a. Is equally divided between kinetic energy and potential energy
   b. Is either all kinetic energy or all potential energy, at any one instant
   c. Can never be negative
   d. Is always constant
   e. None of the above

3) A 30 N stone is dropped from a height of 10.0 m and strikes the ground with a velocity of 7.0 m/s. What average force of air friction acts on it as it falls?
   a. 22.5 N
   b. 33.2 N
   c. 45.7 N
   d. 19.2 N
   e. 7.9 N



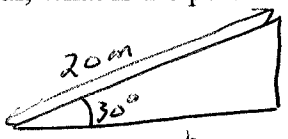
$m = \frac{30N}{9.8 m/s^2} = 3.06 kg$ $\quad mgh - F_f h = \frac{1}{2}mv^2$

$(30 \cdot 10m) - F_f \cdot 10m = \frac{1}{2}(3.06kg)(7m/s)^2$

$300 - 10F_f = 74.97$

$F_f = 22.5N$

4) A 600N person runs up a flight of stairs in 20 s. If the length of the stairs is 20 m long and makes an angle of 30° from the horizontal, what is the person's power output?
   a. 100 W
   b. 300 W
   c. 600 W
   d. 1200 W
   e. 3000 W



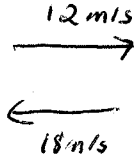
$\sin 30° = \frac{h}{20m}$

$h = 10m$

$W = mgh$

$power = \frac{mgh}{20s} = \frac{6000}{20} = 300\,W$

5) A 0.060 kg tennis ball, initially moving at a speed of 12 m/s, is struck by a racket causing it to rebound in the opposite direction at a speed of 18 m/s. What is the change of momentum of the ball?
   a. 0.36 kg m/s
   b. 0.72 kg m/s
   c. 1.1 kg m/s
   d. 1.8 kg m/s
   e. 2.2 kg m/s



$\Delta p = mv_f - mv_i$

$= .06kg(18 m/s) - .06kg(-12 m/s)$

$= 1.8\ kg\ m/s$

6) A slingshot shoots a rock, and then a steel ball with twice the mass of the rock. The force exerted by the slingshot in each case is the same and lasts for the same amount of time. What can we say about the momentum and velocity of the rock and the ball?

a. The ball has a greater momentum and a greater velocity
b. The ball has a greater momentum, but the rock has a greater velocity.
c. The ball has a greater momentum and they have the same velocity
d. They have the same momentum and the same velocity
e. They have the same momentum, but the rock has a greater velocity

same F
same t
same Δp
$p = mv$
rock smaller mass → larger velocity

7) A block at rest on a horizontal frictionless surface with mass 10 kg compresses a spring by 0.2 m. The spring has a spring constant of 500 N/m. The spring beings to uncompress and the block begins to move. When the spring is compressed by 0.1 m, what is the velocity of the block?

a. 1.50 m/s
b. 1.22 m/s
c. 2.0 m/s
d. 1.41 m/s
e. 2.50 m/s

$\frac{1}{2}kx_1^2 = \frac{1}{2}kx_2^2 + \frac{1}{2}mv^2$ conserve Energy

$500(.2)^2 = 500(.1)^2 + 10(v^2)$

$v = 1.22\ m/s$

8) To pass a truck on a flat road, your car with mass 1.3×10^3 kg needs to accelerate from 13.4 m/s to 17.9 m/s in 3.0 s. What is the minimum power required for this pass?

a. 3×10^4 W
b. 1×10^4 W
c. 7×10^4 W
d. 500 W
e. 5000 W

$W = \Delta K$

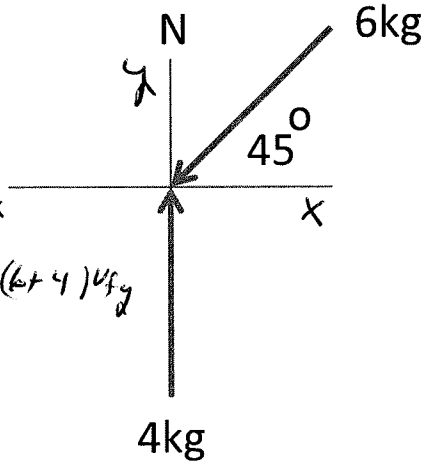
$\text{power} = \frac{W}{t} = \frac{\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2}{3s} = \frac{\frac{1}{2}1.3\times10^3 kg\,(17.9^2 - 13.4^2)}{3s}$

$= 3\times10^4\ W$

9) A 4.0 kg object is moving at 5.0 m/s NORTH. It strikes a 6.0 kg object that is moving SOUTHWEST at 2.0 m/s. The objects have a completely inelastic(stick together) collision. The speed of the 4.0 kg object after the collisions is

a. 1.20 m/s
b. 3.20 m/s
c. 2.11 m/s
d. 1.43 m/s
e. 1.55 m/s

conserve momentum



x: $6\,kg \cdot 2\,m/s \cdot \cos 45^\circ = (6+4)v_{fx}$

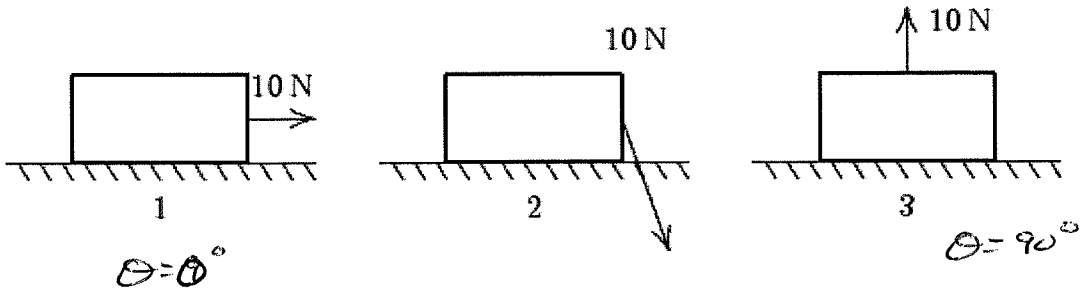
y: $4\,kg \cdot 5\,m/s - 6\,kg \cdot 2\,m/s \sin 45^\circ = (6+4)v_{fy}$

$v_{fx} = .849\ m/s$

$v_{fy} = 1.15\ m/s$

$v_f = \sqrt{v_{fx}^2 + v_{fy}^2}$

$= 1.43\ m/s$



$\theta = 0°$ $\theta = 90°$

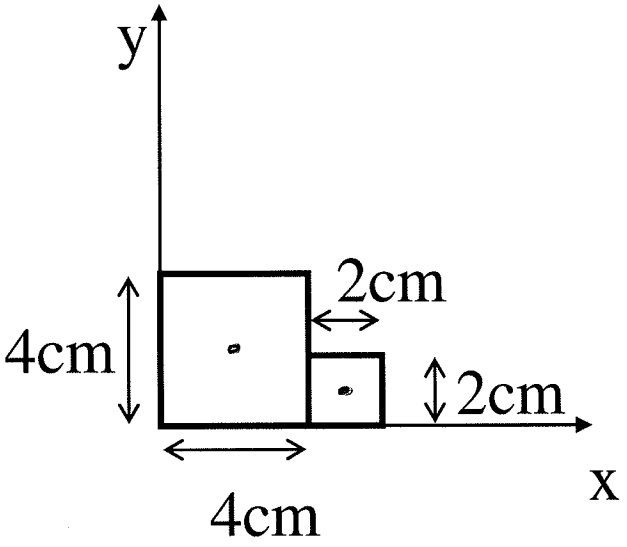
10) A crate moves 10 m to the right on a horizontal surface as a woman pulls it with a force of 10 N. Rank the situations shown according to the work done by her force, least to greatest

a. 1,2,3
b. 2,1,3
c. 2,3,1
d. 1,3,2
e. 3,2,1

$W = F d \cos\theta$

11) Two squares are shown in the figure. The larger square has twice the mass of the smaller square. Find the center of mass of the two squares.

a. Xcm=4cm; Ycm=2cm
b. Xcm=5/3 cm; Ycm = 3cm
c. Xcm=5/3cm; Ycm = 5/3cm
d. Xcm= 3cm;Ycm= 3cm
e. Xcm= 3cm; Ycm =5/3cm



$$X_{cm} = \frac{2M \cdot 2cm + M \cdot 5cm}{2M+M} = \frac{9}{3} = 3$$

$$Y_{cm} = \frac{2M \cdot 2cm + M \cdot 1cm}{2M+M} = \frac{5}{3}$$

12) A 3-g bullet is fired horizontally into a 10 kg block of wood suspended by a rope from the ceiling. The block swings in an arc, rising 3 mm above its lowest position. The velocity of the bullet was:

a. Cannot be determined
b. 800 m/s
c. 400 m/s
d. 1600 m/s
e. 2400 m/s

Conserve momentum

$mv_i = Mv_f$

$.003kg\, v_i = (10.003kg)\, v_f$

$v_f = .0002999\, v_i$

Conserve Energy

$\frac{1}{2}Mv_f^2 = Mgh$

$v_f^2 = 2gh$

$(.0002999 v_i)^2 = 2gh$

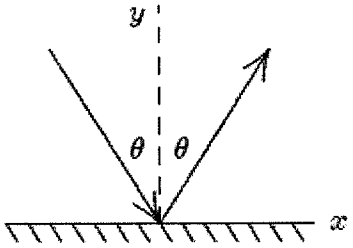
$v_i = 800\ m/s$

13) A ball of mass m and speed v bounces off the floor as shown. The speed of the ball does not change after the collision. The magnitude of the change of momentum of the ball is:

a. 0
b. 2mvsinθ
c. mvsinθ
(d.) 2mvcosθ
e. 2mv

$p_{x_i} = mv\sin\theta$ $p_{xf} = mv\sin\theta$ $\Delta p_x = 0$

$p_{y_i} = -mv\cos\theta$ $p_{yf} = mv\cos\theta$ $\Delta p_y = 2mv\cos\theta$



14) A 3.0 kg cart, moving to the right with a speed of 1.0 m/s, has a head on collision with a 5.0 kg cart that is initially moving to the left with a speed of 2 m/s. After the collision, the 3.0 kg cart is moving to the left with a speed of 1 m/s. This collision is:

a. Elastic
(b.) Inelastic and carts are not stuck together
c. Inelastic and carts are stuck together
d. Cannot be determined

conserve momentum

$3 \cdot 1\ m/s + 5 \cdot (-2\ m/s) = 3 \cdot (-1\ m/s) + 5 \cdot v_f$

$v_f = -\frac{4}{5}\ m/s$

K.E not conserved

$v_{f_1} \neq v_{f_2}$ so not stuck together

15) I drag a 20 kg sack 5 m along a horizontal floor. The sack is moved at a constant velocity of 3 m/s against a 100 N frictional force. What is the net work done on the sack of grain?

(a.) 0 J
b. 100 J
c. 500 J
d. 1000 J
e. Cannot be determined

$W = \Delta K$ $\Delta K = 0$

16) Identical red and blue balls are launched with the same initial speed but different angles. The red ball travels a further horizontal distance than the blue ball. How do the final mechanical energies compare when they hit the ground. Ignore friction.

a. The red ball has more mechanical energy at the end
b. The blue ball has more mechanical energy at the end
(c.) The balls have the same mechanical energy at the end
d. The initial angles must be known to answer this question
e. The initial speed must be known to answer this question

same v_i so same K.E. at beginning

so same E at End