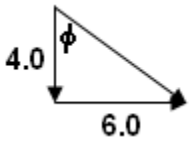
Motion and force in a gravitational field

Home Assignment Vectors, Energy and Momentum

Name: _____ ANSWERS _____ (37 marks total)

Maximum 2 marks to be deducted for incorrect units and significant figures.

1. Rain drops falling vertically have a terminal velocity of 4.00 ms^{-1}. They reach a zone in the atmosphere where the wind is blowing horizontally at a constant 6.00 ms^{-1}. At what angle to the vertical do the drops now move? Include a diagram with your answer. (2 marks)

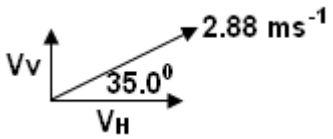


[1 mark]

$\phi = \tan^{-1} (6 \div 4)$
$= 56.3^0$

<u>the drops move 56.3^0 to the vertical</u> **[1 mark]**

2. A bird is flying upwards at an angle of 35.0^0 to the horizontal at a velocity of 2.88 ms^{-1}. What are the vertical and horizontal components of the bird's velocity? (2 marks)

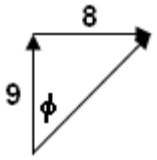


$V_H = 2.88 \cos 35$
<u>$V_H = 2.36\ ms^{-1}$</u> **[1 mark]**

$V_V = 2.88 \sin 35$
<u>$V_v = 1.65\ ms^{-1}$</u> **[1 mark]**

3. A baseball travelling at a velocity of 8.00 ms^{-1} west is hit by the batsman and ends up moving north at a velocity of 9.00 ms^{-1}. What is the resultant change in velocity? (3 marks)

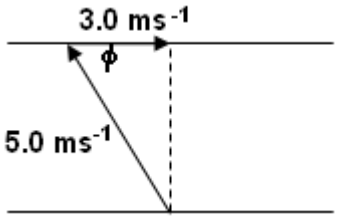
$u = 8\ ms^{-1}$ W
$v = 9\ ms^{-1}$ N
$v - u = 9$ N $- 8$ W
$= 9$ N $+ 8$ E



$v - u = \sqrt{(9^2 + 8^2)}$
$= 12.04\ ms^{-1}$ **[1 mark]**
$\phi = \tan^{-1} (8 \div 9)$
$= 41.63^0$ **[1 mark]**

<u>$\Delta V = 12.0\ ms^{-1}$ N 41.6^0 E</u> **[1 mark]**

4. A boat's speed in still water is 5.00 ms^{-1}. If the boat is to travel directly across a river whose current has a speed of 3.00 ms^{-1}, at what angle to the bank must the boat head? Draw a labelled diagram with your answer. (2 marks)



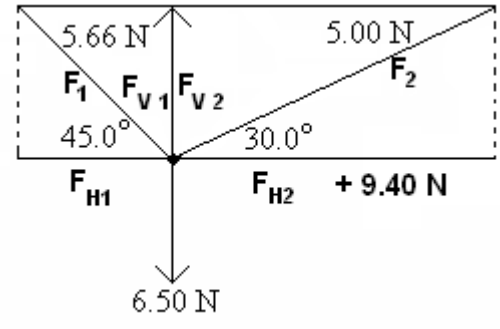
[1 mark]

the maximum speed is 5.00 ms^{-1} so that must be the hypotenuse of the right triangle.

$\phi = \cos^{-1} (3 \div 5)$
<u>$\phi = 53.1^0$ to the bank</u>

[1 mark]

5. Consider the diagram of forces shown on the right.
   Calculate the total force acting on the object. (5 marks)

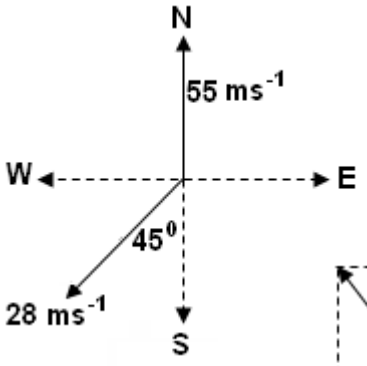


Vertical Forces = 6.50 – [(5.66 sin 45) + (5 sin 30)]
= 6.50 – 6.50
= 0 N [2 marks]

Horizontal forces = (5.66 cos 45) – [9.40 + (5 cos 30)]
= 4.00 – 13.83
= 9.83 N right [2 marks]

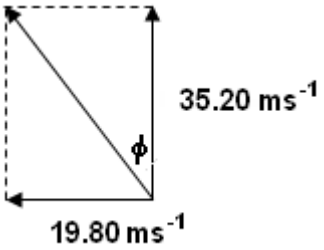
<u>Resultant = 9.83 N right</u> [1 mark]

6. A plane whose airspeed is 55.0 ms^{-1} heads due north. But a 28.0 ms^{-1} northeast wind (i.e., coming from the northeast) suddenly begins to blow. What is the resulting velocity of the plane with respect to the ground? (5 marks)



Resolve 28 ms^{-1} to horizontal and vertical components
V_v = 28 sin 45 = 19.79898 ms^{-1} South
V_H = 18 cos 45 = 19.79898 ms^{-1} West [1 mark]

Vertical velocity = 55 – 19.79898 = 35.201 ms^{-1} North
Horizontal velocity = 19.79898 ms^{-1} West [1 marks]



$$V = \sqrt{(35.2^2 + 19.799^2)}$$
= 40.4 ms^{-1} [1 mark]
$\phi = \tan^{-1}(19.8 \div 35.2)$
$= 29.4^0$ [1 mark]

<u>$V = 40.4\ ms^{-1}$ N 29.4^0 W</u> [1 mark]

7. A pitcher throws a baseball due south towards the batter at 20.0 ms^{-1}. The batter just touches the ball but causes it to continue in the same direction but at 15.0 ms^{-1} still sount. If the ball's change in velocity occurred in 0.200 s, what was the ball's acceleration? (3 marks)

u = 20 ms^{-1} S
v = 15 ms^{-1} S
v – u = 15 S – 20 S
= 15 S + 20 W
v – u = 5.00 ms^{-1} W
[1 mark]

$$a = \frac{v - u}{t} = \frac{5}{0.2}$$

<u>a = 25.0 ms^{-1} West</u> [1 mark value, 1 mark direction]

8. As I watch out of my study window, I see Gipsy, my Persian cat, chasing a lizard (assume it has a mass of 0.144 kg). The Lizard is running at 3.15 ms^{-1} N when, coming to a wall, it spins around running straight under Gipsy and is now travelling at 3.80 ms^{-1} S. What was the change of momentum of the lizard? (3 marks)

$u = 3.15\ ms^{-1}$ N
$v = 3.80\ ms^{-1}$ S
$v - u = 3.8$ S $- 3.15$ N
$= 3.8$ S $+ 3.15$ S
$= 6.95\ ms^{-1}$ S [1 mark]
$m = 0.144$ kg

$\Delta p = m(v - u)$
$= 0.144 \times 6.95$
$\underline{\Delta p = 1.00\ kgms^{-1}\ South}$ [2 marks]

9. Tim is riding his bike (total mass of 70.0 kg) at 4.15 ms^{-1}.
   a. What is Tim's kinetic energy?

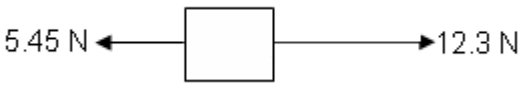
$E_k = \frac{1}{2} mv^2$
$= \frac{1}{2} \times 70 \times 4.15^2$
$= 602.7875$
$\underline{E_k = 603\ J}$ [1 mark]

   b. How much work must Tim do to double his speed?

Work is equivalent to energy so work = E_k [1 mark]

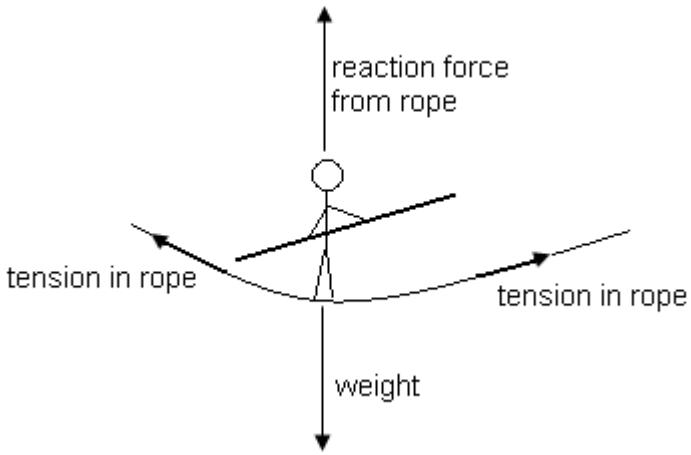
$E_k = \frac{1}{2} mv^2$
$= \frac{1}{2} \times 70 \times 8.3^2$
$= 2411.15$
$\underline{E_k = \text{work} = 2.41 \times 10^3\ J}$ [1 mark]

10. Free body diagrams are useful to show the forces acting.
    a. For the object shown, calculate the net force acting.



net Force = 12.3 – 5.45 = $\underline{6.85\ N}$ [1 mark]

   b. Label all the forces acting in the following situation. (2 marks)



[2 marks]

11. A 0.150 kg ball is thrown straight up into the from the ground.

a. How much kinetic energy does the ball have as it leaves the person's hand? (1 marks)

m = 0.15 kg
u = 6.40 ms^{-1}

$E_k = ½ mv^2$
$= ½ \times 0.15 \times 6.40^2$
$= 3.027$
$\underline{E_k = 3.03\ J}$ **[1 marks]**

b. What is the maximum height the ball will reach assuming no air resistance? (3 marks)

u = 6.40 ms^{-1}
v = 0 ms^{-1}
g = -9.8 ms^{-2}
(opposite direction)

$v^2 = u^2 + 2gs$
$0 = 6.4^2 + (2 \times -9.8 \times s)$
$0 = 40.96 - 19.6s$
$40.96 = 19.6s$
$s = 2.09$ m **[2 marks]**

but already 1.20 ms in the air so total height
$= 2.09 + 1.20$
$= 3.29$ m **[1 mark]**

c. What is the potential energy when the ball is at its highest point? (1 marks)

$E_p = mgh$
$= 0.15 \times 9.8 \times 3.29$
$\underline{E_p = 4.84\ J}$ **[1 mark]**