

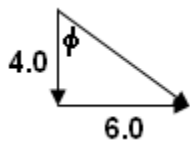
# Motion and force in a gravitational field

## 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  $4.00 \text{ ms}^{-1}$ . They reach a zone in the atmosphere where the wind is blowing horizontally at a constant  $6.00 \text{ ms}^{-1}$ . At what angle to the vertical do the drops now move? Include a diagram with your answer. (2 marks)



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

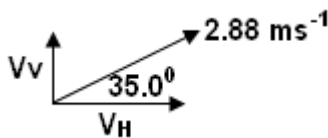
$$= 56.3^\circ$$

the drops move  $56.3^\circ$  to the vertical

[1 mark]

[1 mark]

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



$$V_H = 2.88 \cos 35$$

$$V_H = 2.36 \text{ ms}^{-1}$$

[1 mark]

$$V_V = 2.88 \sin 35$$

$$V_V = 1.65 \text{ ms}^{-1}$$

[1 mark]

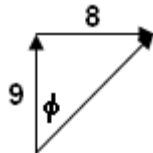
3. A baseball travelling at a velocity of  $8.00 \text{ ms}^{-1}$  west is hit by the batsman and ends up moving north at a velocity of  $9.00 \text{ ms}^{-1}$ . What is the resultant change in velocity? (3 marks)

$$u = 8 \text{ ms}^{-1} \text{ W}$$

$$v = 9 \text{ ms}^{-1} \text{ N}$$

$$v - u = 9 \text{ N} - 8 \text{ W}$$

$$= 9 \text{ N} + 8 \text{ E}$$



$$v - u = \sqrt{(9^2 + 8^2)}$$

$$= 12.04 \text{ ms}^{-1}$$

[1 mark]

$$\phi = \tan^{-1}(8 \div 9)$$

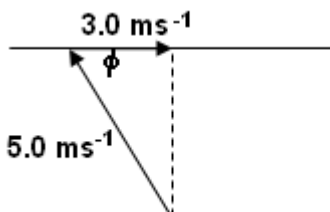
$$= 41.63^\circ$$

[1 mark]

$$\Delta V = 12.0 \text{ ms}^{-1} \text{ N } 41.6^\circ \text{ E}$$

[1 mark]

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



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

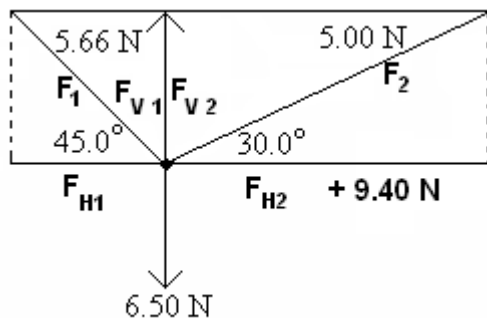
$$\phi = \cos^{-1}(3 \div 5)$$

$$\phi = 53.1^\circ \text{ to the bank}$$

[1 mark]

[1 mark]

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

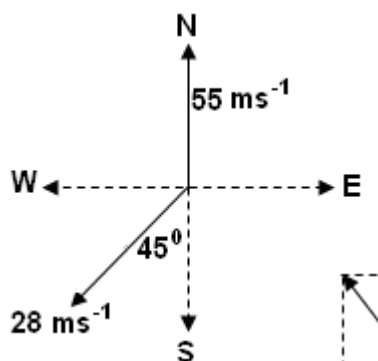


$$\begin{aligned}\text{Vertical Forces} &= 6.50 - [(5.66 \sin 45) + (5 \sin 30)] \\ &= 6.50 - 6.50 \\ &= 0 \text{ N}\end{aligned}\quad [2 \text{ marks}]$$

$$\begin{aligned}\text{Horizontal forces} &= (5.66 \cos 45) - [9.40 + (5 \cos 30)] \\ &= 4.00 - 13.83 \\ &= 9.83 \text{ N right}\end{aligned}\quad [2 \text{ marks}]$$

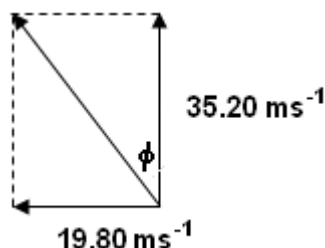
$$\text{Resultant} = 9.83 \text{ N right} \quad [1 \text{ mark}]$$

6. A plane whose airspeed is  $55.0 \text{ ms}^{-1}$  heads due north. But a  $28.0 \text{ ms}^{-1}$  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)



$$\begin{aligned}\text{Resolve } 28 \text{ ms}^{-1} \text{ to horizontal and vertical components} \\ V_v &= 28 \sin 45 = 19.79898 \text{ ms}^{-1} \text{ South} \\ V_h &= 28 \cos 45 = 19.79898 \text{ ms}^{-1} \text{ West}\end{aligned}\quad [1 \text{ mark}]$$

$$\begin{aligned}\text{Vertical velocity} &= 55 - 19.79898 = 35.201 \text{ ms}^{-1} \text{ North} \\ \text{Horizontal velocity} &= 19.79898 \text{ ms}^{-1} \text{ West}\end{aligned}\quad [1 \text{ marks}]$$



$$\begin{aligned}V &= \sqrt{(35.2^2 + 19.799^2)} \\ &= 40.4 \text{ ms}^{-1} \\ \phi &= \tan^{-1}(19.8 \div 35.2) \\ &= 29.4^\circ\end{aligned}\quad [1 \text{ mark}]$$

$$\underline{V = 40.4 \text{ ms}^{-1} \text{ N } 29.4^\circ \text{ W}} \quad [1 \text{ mark}]$$

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

$$\begin{aligned}u &= 20 \text{ ms}^{-1} \text{ S} \\ v &= 15 \text{ ms}^{-1} \text{ S} \\ v - u &= 15 \text{ S} - 20 \text{ S} \\ &= 15 \text{ S} + 20 \text{ W} \\ v - u &= 5.00 \text{ ms}^{-1} \text{ W}\end{aligned}\quad [1 \text{ mark}]$$

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

$$\underline{a = 25.0 \text{ ms}^{-1} \text{ West}} \quad [1 \text{ mark value, 1 mark direction}]$$

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  $3.15 \text{ ms}^{-1}$  N when, coming to a wall, it spins around running straight under Gipsy and is now travelling at  $3.80 \text{ ms}^{-1}$  S. What was the change of momentum of the lizard? (3 marks)

$$u = 3.15 \text{ ms}^{-1} \text{ N}$$

$$v = 3.80 \text{ ms}^{-1} \text{ S}$$

$$\begin{aligned} v - u &= 3.8 \text{ S} - 3.15 \text{ N} \\ &= 3.8 \text{ S} + 3.15 \text{ S} \\ &= 6.95 \text{ ms}^{-1} \text{ S} \end{aligned} \quad [1 \text{ mark}]$$

$$m = 0.144 \text{ kg}$$

$$\Delta p = m (v - u)$$

$$= 0.144 \times 6.95$$

$$\Delta p = 1.00 \text{ kgms}^{-1} \text{ South} \quad [2 \text{ marks}]$$

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

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

$$= \frac{1}{2} \times 70 \times 4.15^2$$

$$= 602.7875$$

$$E_k = 603 \text{ J} \quad [1 \text{ mark}]$$

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

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

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

$$= \frac{1}{2} \times 70 \times 8.3^2$$

$$= 2411.15$$

$$E_k = \text{work} = 2.41 \times 10^3 \text{ J} \quad [1 \text{ mark}]$$

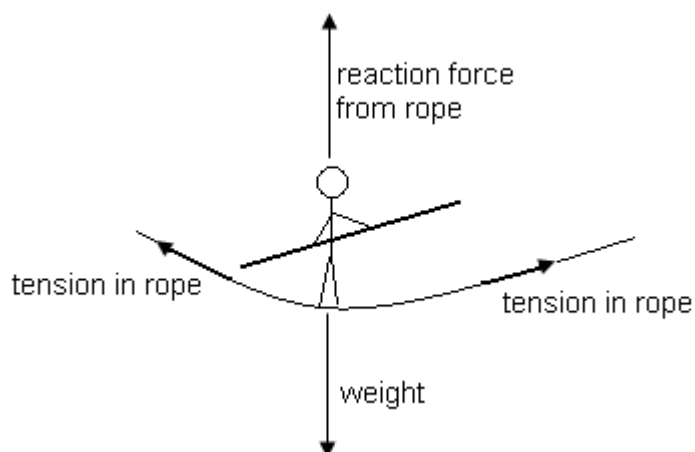
10. Free body diagrams are useful to show the forces acting.  
a. For the object shown, calculate the net force acting.



$$\text{net Force} = 12.3 - 5.45 = 6.85 \text{ N} \quad [1 \text{ mark}]$$

- 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)

$$m = 0.15 \text{ kg}$$

$$u = 6.40 \text{ ms}^{-1}$$

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

$$= \frac{1}{2} \times 0.15 \times 6.40^2$$

$$= 3.027$$

$$\underline{E_k = 3.03 \text{ J}}$$

[1 marks]

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

$$u = 6.40 \text{ ms}^{-1}$$

$$v = 0 \text{ ms}^{-1}$$

$$g = -9.8 \text{ ms}^{-2}$$

(opposite direction)

$$v^2 = u^2 + 2gs$$

$$0 = 6.4^2 + (2 \times -9.8 \times s)$$

$$0 = 40.96 - 19.6s$$

$$40.96 = 19.6s$$

$$s = 2.09 \text{ m}$$

[2 marks]

$$\text{but already } 1.20 \text{ ms in the air so total height}$$

$$= 2.09 + 1.20$$

$$= 3.29 \text{ m}$$

[1 mark]

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

$$E_p = mgh$$

$$= 0.15 \times 9.8 \times 3.29$$

$$\underline{E_p = 4.84 \text{ J}}$$

[1 mark]