KINEMATICS

PROVINCIAL EXAM ASSIGNMENT

1. Which one of the following is a vector quantity?

   A. time
   B. speed
   C. energy
   D. displacement

2. A car is travelling at a constant speed of 26.0 m/s down a slope which is 12.0° to the horizontal. What is the vertical component of the car's velocity?

   A. 5.41 m/s
   B. 9.80 m/s
   C. 25.4 m/s
   D. 26.0 m/s

3. Which one of the following best describes the motion of a projectile close to the surface of the Earth? (assume no friction)

	VERTICAL ACCELERATION	HORIZONTAL SPEED
A.	constant	constant
B.	constant	changing
C.	changing	constant
D.	changing	changing

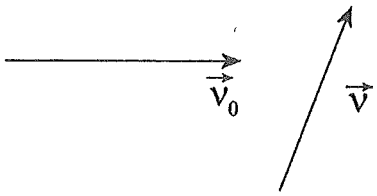
4. A projectile is launched over level ground with a speed of 240 m/s at 35° to the horizontal. If friction is negligible, what is the height of the projectile 17 s after launch?

   A. 9.2×10^2 m
   B. 1.9×10^3 m
   C. 2.7×10^3 m
   D. 5.5×10^3 m

5. A passenger jet needs to reach a speed of 100 m/s on the runway for takeoff. If the runway is 2.5×10^3 m long, what minimum average acceleration from rest is needed?

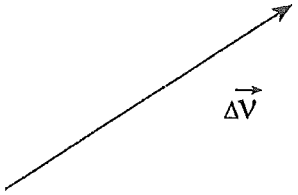
   A. 0.040 m/s^2
   B. 2.0 m/s^2
   C. 4.0 m/s^2
   D. 10 m/s^2

6. Initial velocity vector $\vec{v}_0$ and final velocity vector $\vec{v}$ are shown below.

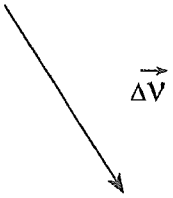


Which of the following represents the change in velocity $\Delta\vec{v}$?

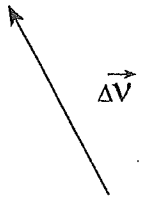
A.



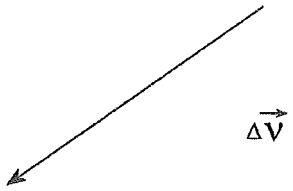
B.



C.



D.



7. If friction is negligible, which of the following is true for the velocity components of projectiles?

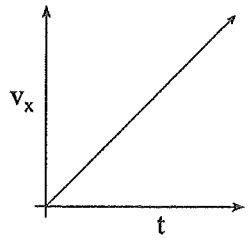
	HORIZONTAL VELOCITY COMPONENT	VERTICAL VELOCITY COMPONENT
A.	constant	constant
B.	constant	changes
C.	changes	constant
D.	changes	changes

8. At what speed must a ball be thrown upwards to reach a maximum height of 25 m?

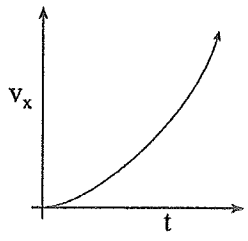
A. 2.6 m/s
B. 22 m/s
C. 2.5×10^2 m/s
D. 3.1×10^3 m/s

9. Which of the following graphs represents the horizontal velocity component (v_x) versus time for a projectile thrown horizontally off a cliff? (Ignore air resistance.)

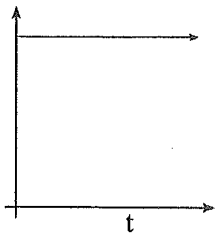
A.



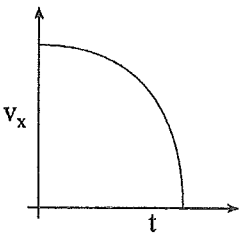
B.



C.



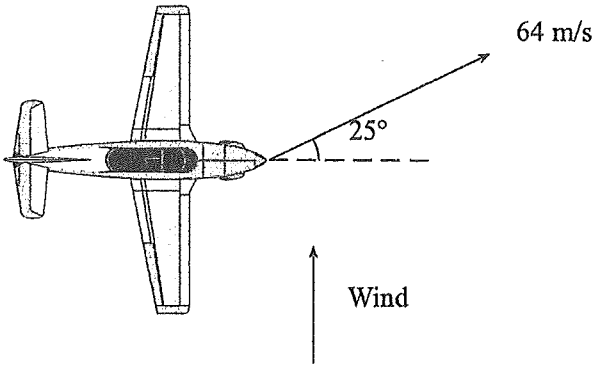
D.



10. A skier accelerates uniformly from 5.2 m/s to 12.8 m/s at 0.85 m/s^2. Find the distance she travels.

A. 7.7 m
B. 8.9 m
C. 11 m
D. 80 m

11. A pilot points an aircraft due east, while the wind blows from the south.



The resultant velocity of the aircraft over the ground is 64 m/s, 25° N of E . At what speed does the wind blow?

A. 2.6 m/s
B. 27 m/s
C. 30 m/s
D. 58 m/s

12. When a 2.0 kg rock is dropped from a cliff it hits the beach at 24 m/s. At what speed would a 4.0 kg rock, dropped from the same cliff, hit the beach? Ignore friction.

A. 12 m/s
B. 24 m/s
C. 34 m/s
D. 48 m/s

13. An airplane which was flying eastward is later flying southward at the same speed. Which vector shows the airplane's change in velocity?

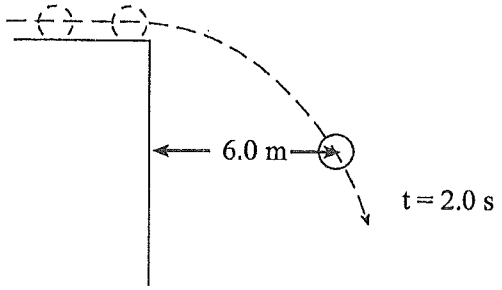
A.

B.

C.

D.

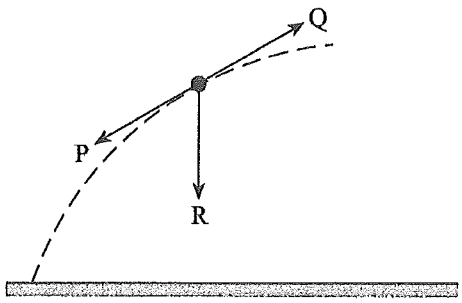
14. At $t = 0$ s a ball rolls off the edge of a vertical cliff. At $t = 2.0$ s the ball is 6.0 m from the cliff as shown.



How far is the ball from the cliff at $t = 4.0$ s?

A. 6.0 m
B. 9.0 m
C. 12 m
D. 24 m

15. The projectile shown below has an acceleration which is



A. zero.
B. in the direction of P.
C. in the direction of Q.
D. in the direction of R.

16. Pamela swims at 2.8 m/s relative to the water, heading west. The current flows south at 1.2 m/s. Find Pamela's resultant direction.

A. 23° S of W
B. 25° S of W
C. 23° N of W
D. 25° N of W

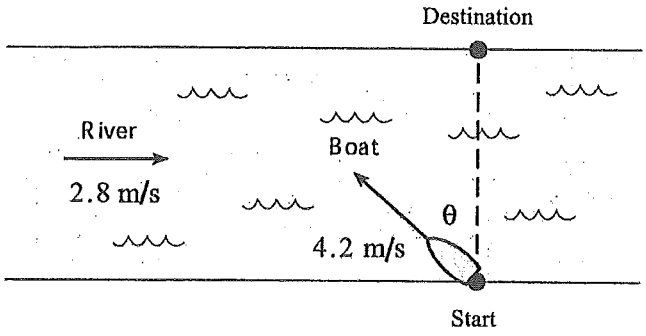
17. An object is launched at 65° to the horizontal with an initial speed of 25 m/s. What is the maximum height reached by this object?

A. 5.7 m
B. 26 m
C. 32 m
D. 150 m

18. A ball is kicked into the air from the surface of a playing field. If friction is negligible, the ball will follow a path that is

A. circular.
B. elliptical.
C. parabolic.
D. hyperbolic.

19. A boat shown below travels at 4.2 m/s relative to the water, in a river flowing at 2.8 m/s.



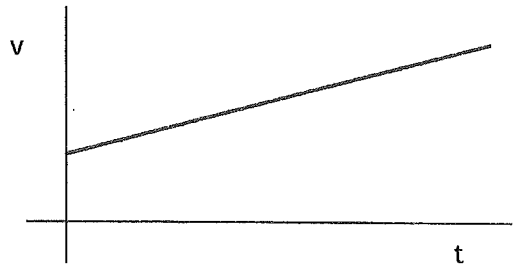
At what angle θ must the boat head to reach the destination directly across the river?

A. 34°
B. 42°
C. 48°
D. 56°

20. A ball is thrown vertically upward at 20 m/s from a height of 30 m above the ground. What is its speed on impact with the ground below?

A. 14 m/s
B. 24 m/s
C. 31 m/s
D. 44 m/s

21. The graph shown below displays velocity v versus time t for a moving object.



The slope of this graph represents the object's

A. mass.
B. momentum.
C. acceleration.
D. displacement.

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22. A rock is released from the top of a 30 m high cliff at the same time as a ball is thrown upwards from the base of the cliff at 20 m/s. How much time elapses before they collide?

A. 1.0 s
B. 1.2 s
C. 1.5 s
D. 2.5 s

23. A ball is rolled off a horizontal roof at 16 m/s. After leaving the roof, how long will the ball take to reach a speed of 18 m/s?

A. 0.20 s
B. 0.84 s
C. 1.8 s
D. 2.5 s

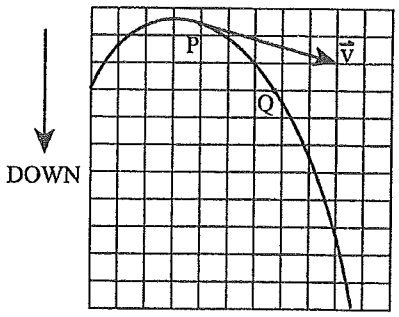
24. A rock is thrown horizontally with an initial speed of 41 m/s from a cliff 32 m above a lake. If air resistance is negligible, what is the velocity of the rock at the moment of impact with the water?

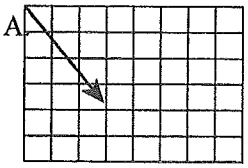
A. 45 m/s, 23^0 from the horizontal
B. 45 m/s, 67^0 from the horizontal
C. 48 m/s, 31^0 from the horizontal
D. 48 m/s, 59^0 from the horizontal

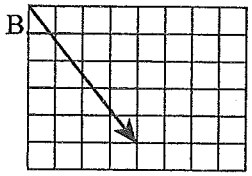
25. A bus is travelling forward at a constant velocity. A student sitting in the bus drops a ball which hits the floor of the bus. Relative to a stationary observer, outside the bus and to one side, which statement is true?

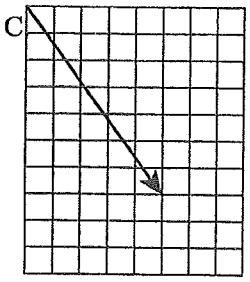
A. The ball falls vertically.
B. The ball hits the floor of the bus in front of the student.
C. The ball hits the floor of the bus in behind the student.
D. The ball hits the floor of the bus directly beneath the student's hand.

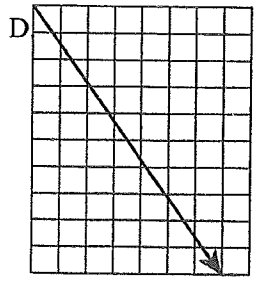
26. The diagram below shows the path of a projectile when air friction is insignificant. If the vector **v** represents the velocity of the projectile at point **P**, which of the choices represents the velocity vector at point **Q**?



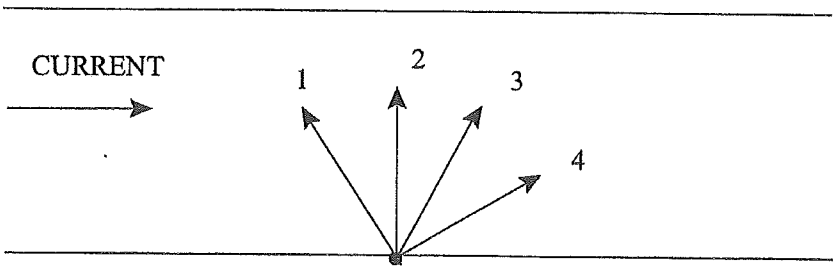








27. A motorboat at point X must cross a river flowing as shown in the diagram below. If the boat travels at a fixed speed relative to the water, in which direction should the boat head in order to reach the other side in the least amount of time?



A. 1
B. 2
C. 3
D. 4

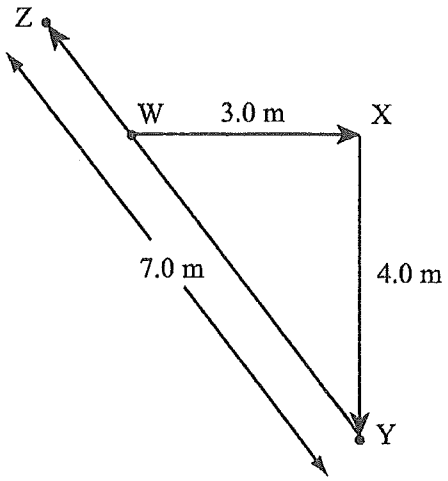
28. A car travels 10.0 km due east and then 12.0 km in a direction 45^0 north of west. What is the magnitude of the car's displacement?

A. 6.6 km
B. 8.6 km
C. 15.6 km
D. 22.0 km

29. An object is fired at a speed of 26 m/s at an angle of 63^0 above the horizontal. What is the speed of the object when it is 6.2 m above the point from which it was fired?

A. 4.0 m/s
B. 9.8 m/s
C. 20 m/s
D. 24 m/s

30. A man move from W to X to Y to Z in the diagram below. What is the magnitude of his final displacement from W?



A. 2.0 m
B. 8.6 m
C. 12 m
D. 14 m

1. A 1.50 kg projectile is launched at 18.0 m/s from level ground. The launch angle is 26.0° above the horizontal. (Assume negligible friction.)

   a) What is the maximum height reached by this projectile? **(5 marks)**

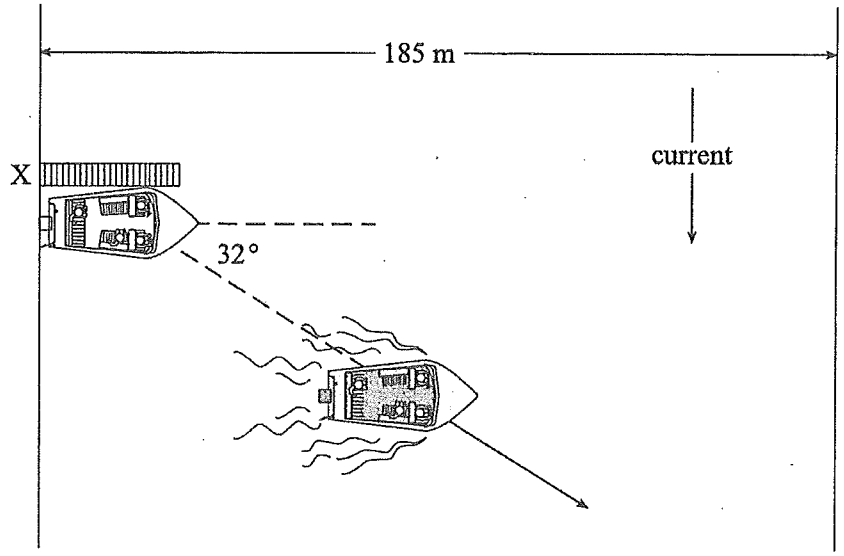
   b) How fast will the projectile be travelling when it is at its maximum height? **(2 marks)**

2. A projectile is launched over level ground at 35 m/s at an angle of 24^0 above the horizontal. Friction is negligible.

a) What is the time of flight of this projectile? **(3 marks)**

b) What is the velocity (magnitude and direction) of this projectile 2.5 s after launch? **(4 marks)**

3. A boat which can travel at 5.6 m/s in still water heads due east across a river from a dock at X. The boat's resultant path is 32° south of east.



a) What is the speed of the current? **(3 marks)**

b) How long will it take the boat to reach the far shore if the river is 185 m wide? **(2 marks)**

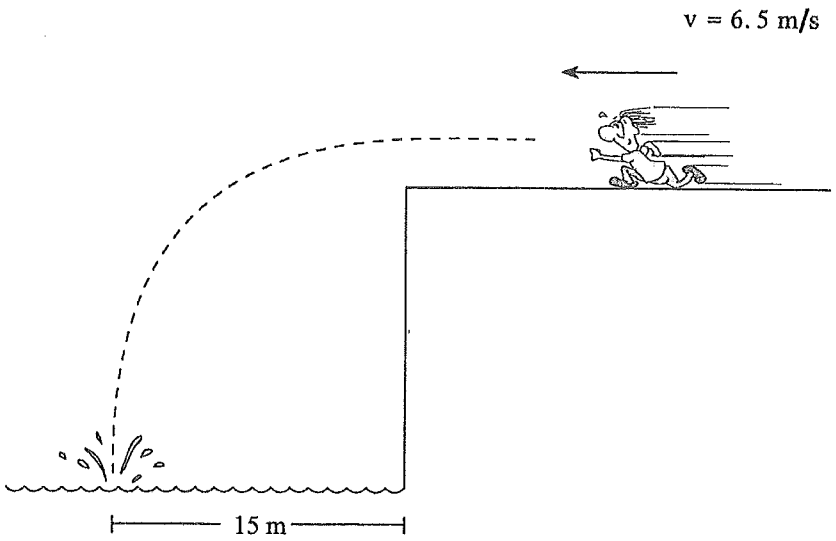
c) How far downstream will the boat be at this time? **(2 marks)**

4. A projectile is launched over level ground at 85 m/s, 25° above the horizontal. Air resistance may be ignored.

a) Calculate the range (horizontal distance) of the projectile. **(5 marks)**

b) Using principles of physics, comment on the horizontal and vertical components of the projectile's velocity and acceleration during the flight. **(4 marks)**

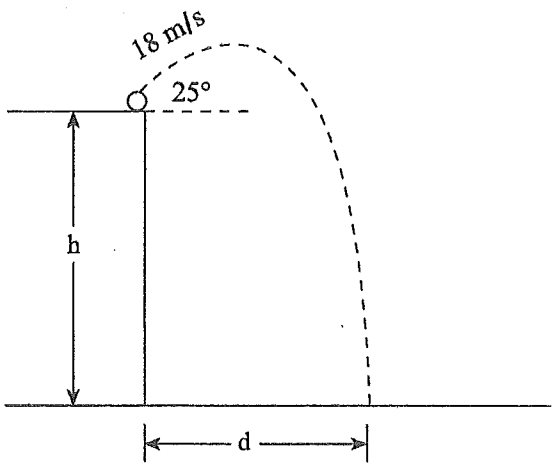
5. Mike runs horizontally off a cliff at 6.5 m/s and lands in the water 15 m from the base of the cliff.



a) How long does it take Mike to hit the water? **(3 marks)**

b) How high is the cliff? **(4 marks)**

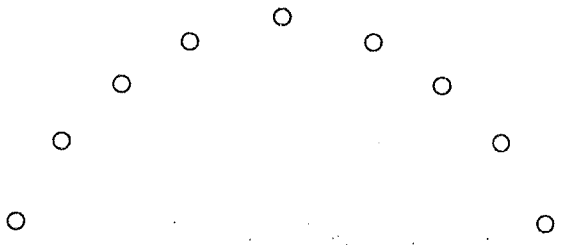
6. A rock is thrown from a cliff top at 18 m/s, 25° above the horizontal. It lands on the beach 4.2 s later.



a) What is the height **h** of the cliff? **(4 marks)**

b) How far from the base of the cliff **d** did the rock land? **(3 marks)**

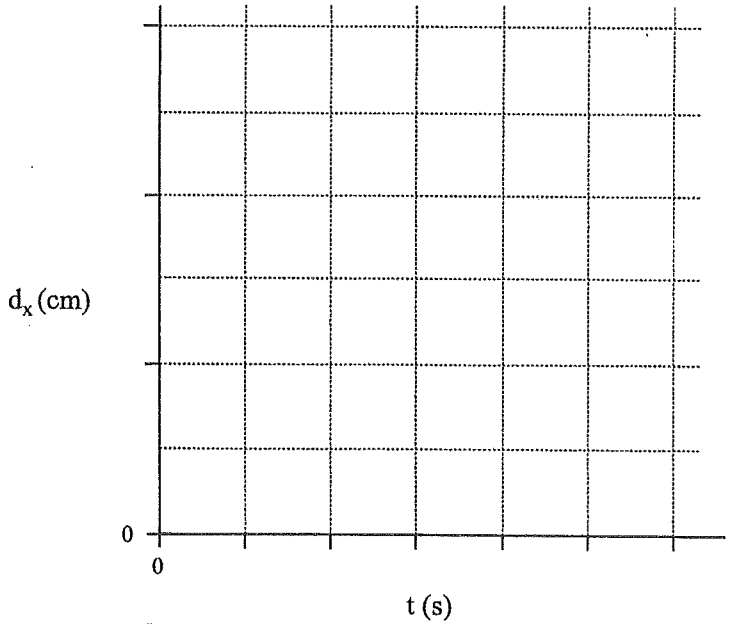
7. A student collects data from the path of a projectile similar to that shown in the diagram.



The student records the following data for horizontal displacement from the initial launch position as a function of time.

d_x (cm)	0.0	0.5	0.9	1.5	1.9	2.5	3.1
t (s)	0.000	0.020	0.040	0.060	0.080	0.100	0.120

a) Plot a graph of d_x vs. t on the graph below. **(2 marks)**



b) Calculate the slope of the line, expressing the answer in appropriate units. **(2 marks)**

c) Based on this data and graph, make a statement about the behaviour of projectiles.
(1 mark)

_____

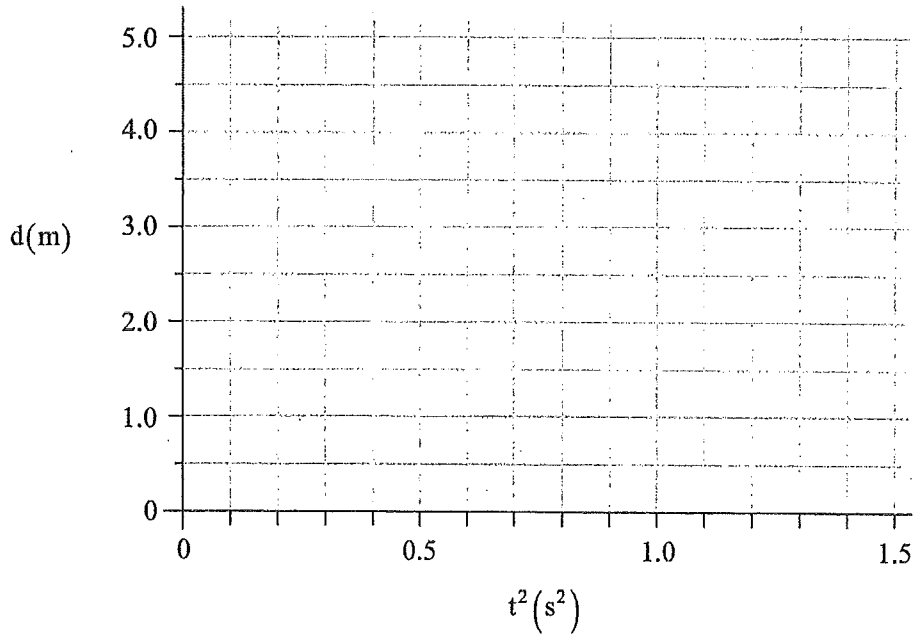
_____

8. The first colonists on Mars conduct a physics experiment by dropping a small mass (from rest) and recording its displacement at regular time intervals. This data is shown below.

d (m)	t (s)	
0.30	0.40	
0.60	0.60	
1.20	0.80	
1.80	1.00	
2.70	1.20	

a) Plot a graph of displacement versus time squared and draw the best fit straight line.

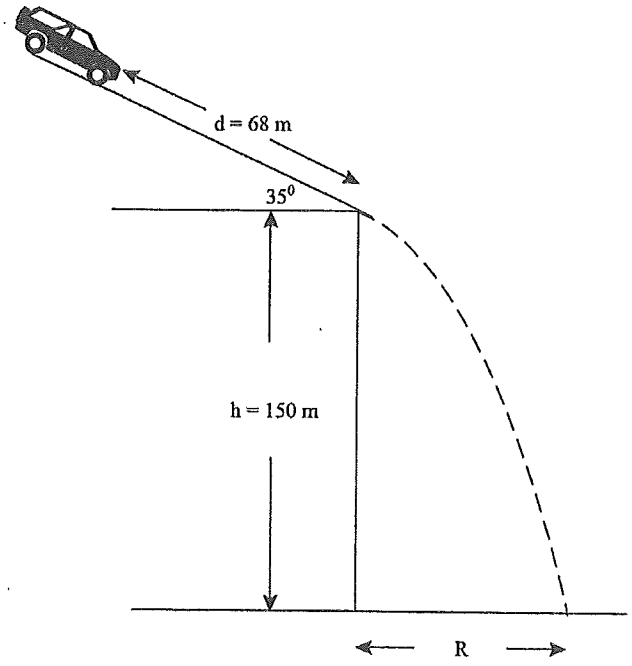
(2 marks)



b) Determine the slope of the line. **(2 marks)**

c) Based on this experiment, what is the acceleration due to gravity on Mars? **(1 mark)**

9. A careless driver forgets to set the emergency brakes of their vehicle. The vehicle starts from rest and rolls 68 m along a surface inclined 35^0 to the horizontal, as shown in the diagram below. The cliff is 150 m high.



If friction is negligible, how far (R) from the base of the cliff will the truck hit level ground? **(10 marks)**

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10. An aircraft with an airspeed of 250 km/h heads 19^0 east of north. When it encounters a wind, its velocity relative to the ground becomes 260 km/h due north.

a) Write the vector equation for the velocity of the wind relative to the ground. **(1 mark)**

b) Draw and label the vector diagram which represents the vector equation from part (a). **(3 marks)**

c) What is the velocity of the wind relative to the ground? **(5 marks)**

OMIT

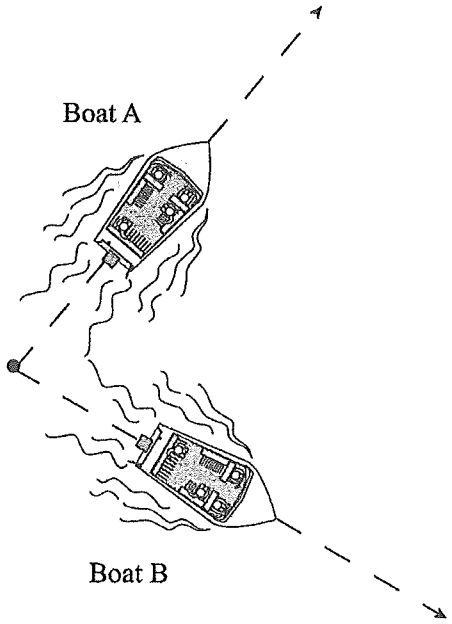
11. To reach its destination on time, an aircraft is required to maintain a ground speed of 650 km/h in a direction of 60^0 south of west. A wind is encountered that is blowing at 40 km/h in a direction of 45^0 north of west.

a) Write the vector equation for the velocity of the aircraft relative to the wind. **(1 mark)**

b) Draw and label the vector diagram which represents the vector equation from part (a). **(3 marks)**

c) What is the velocity of the plane relative to the wind? **(5 marks)**

12. Boats A and B both leave the same point at the same time. Boat A has a velocity of 25 km/h with a heading of 50^0 north of east, while Boat B has a velocity of 35 km/h with a heading of 30^0 south of east.



a) What is the velocity of Boat B relative to Boat A? **(5 marks)**

b) How far apart the two boats after 2.0 hours? **(2 marks)**

VECTOR KINEMATICS
PROVINCIAL EXAMINATION ASSIGNMENT
ANSWER KEY / SCORING GUIDE

PART A: Multiple Choice (each question worth ONE mark)

Q	K	Q	K
1.	D	16.	A
2.	A	17.	B
3.	A	18.	C
4.	A	19.	B
5.	B	20.	C
6.	C	21.	C
7.	B	22.	C
8.	B	23.	B
9.	C	24.	C
10.	D	25.	D
11.	B	26.	C
12.	B	27.	B
13.	D	28.	B
14.	C	29.	D
15.	D	30.	A

1. A 1.50 kg projectile is launched at 18.0 m/s from level ground. The launch angle is 26.0° above the horizontal. (Assume negligible friction.)

a) What is the maximum height reached by this projectile? **(5 marks)**

$v_x = v_o \sin 26° = 7.89 \text{ m/s}$ **1 mark**

$v_f^2 = v_0^2 + 2ad$

$0 = 7.89^2 + 2(-9.8)(d)$ **4 marks**

$d = 3.18 \text{ m}$

Alternate Energy Solution:

$E_{TOTAL} = \frac{1}{2}mv^2 = \frac{1}{2}(1.5)(18.0)^2 = 243 \text{ J}$ **1½ marks**

$E_{TOTAL} = E_{p_{(TOP)}} + E_{k_{TOP}}$ **1 mark**

$E_T = mgh + \frac{1}{2}mv_f^2$

$243 = (1.5)(9.8)h + \frac{1}{2}(1.5)(18\cos 26)^2$ **1½ marks**

$243 = 14.7h + 196$

$3.20 = h$ **1 mark**

b) How fast will the projectile be travelling when it is at its maximum height? **(2marks)**

$v = v_o \cos 26° = 16.2 \text{ m/s}$ **2 marks**

2. A projectile is launched over level ground at 35 m/s at an angle of 24° above the horizontal. Friction is negligible.

a) What is the time of flight of this projectile? **(3 marks)**

$$t = -\frac{2v\sin\theta}{a}$$

$$= \frac{-2(35)\cdot\sin 24}{-9.8}$$

$$= 2.9 \text{ s} \quad \leftarrow \textbf{3 marks}$$

b) What is the velocity (magnitude and direction) of this projectile 2.5 s after launch? **(4 marks)**

$$v_x = v\cdot\cos\theta$$

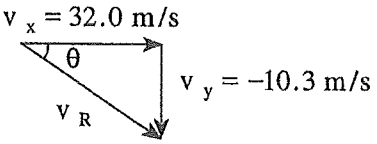
$$= 35 \text{ m/s}\cdot\cos 24$$

$$= 32.0 \text{ m/s} \quad \leftarrow \textbf{1 mark}$$

$$v_{y_f} = v_{y_i} + at$$

$$= (35 \text{ m/s}\cdot\sin 24) + (-9.8 \text{ m/s}^2 \cdot 2.5 \text{ s})$$

$$= -10.3 \text{ m/s} \quad \leftarrow \textbf{1 mark}$$



$$\therefore v_R^2 = v_x^2 + v_{y_f}^2$$

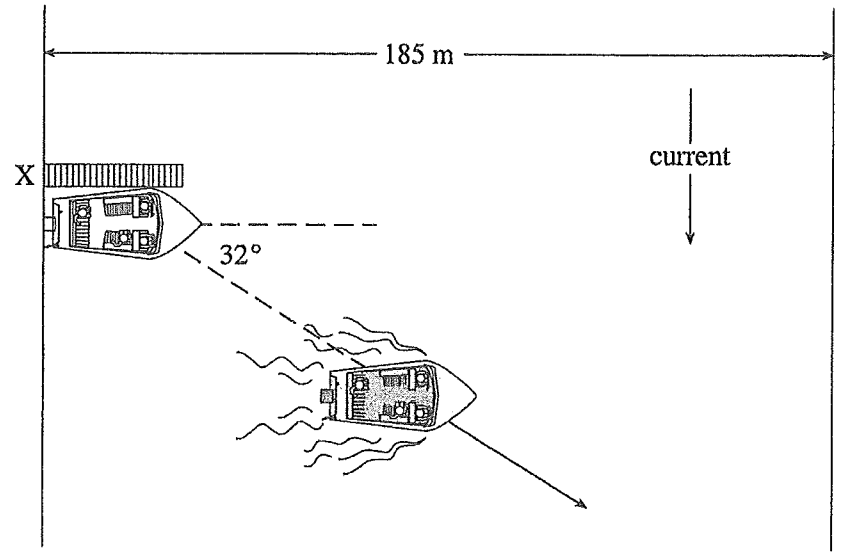
$$= (32.0 \text{ m/s})^2 + (10.3 \text{ m/s})^2$$

$$\therefore v_R = 34 \text{ m/s} \quad \leftarrow \textbf{1 mark}$$

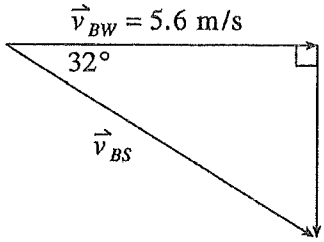
$$\theta = \tan^{-1}\left(\frac{10.3 \text{ m/s}}{32.0 \text{ m/s}}\right)$$

$$= 18° \text{ (below the horizontal)} \quad \leftarrow \textbf{1 mark}$$

3. A boat which can travel at 5.6 m/s in still water heads due east across a river from a dock at X. The boat's resultant path is 32° south of east.



a) What is the speed of the current? **(5 marks)**



← **2 marks**

$$\tan 32° = \frac{v_{WS}}{5.6 \text{ m/s}}$$

$$v_{WS} = 5.6 \tan 32°$$

$$v_{WS} = 3.5 \text{ m/s} \quad \leftarrow \textbf{3 marks}$$

b) How long will it take the boat to reach the far shore if the river is 185 m wide? **(2 marks)**

$$v_E = \frac{d_E}{t} \quad \leftarrow \tfrac{1}{2} \textbf{ mark}$$

$$5.6 = \frac{185}{t}$$

$$t = \frac{185}{5.6} \quad \leftarrow \textbf{1 mark}$$

$$t = 33 \text{ s} \quad \leftarrow \tfrac{1}{2} \textbf{ mark}$$

4. A projectile is launched over level ground at 85 m/s, 25° above the horizontal. Air resistance may be ignored.

a) Calculate the range (horizontal distance) of the projectile. **(5marks)**

$$v_{y_i} = v\sin\theta$$
$$= 85\text{ m/s}\cdot\sin 25$$
$$= 35.9\text{ m/s}$$
$$v_x = v\cos\theta$$
$$= 85\text{ m/s}\cdot\cos 25$$
$$= 77.0\text{ m/s}$$
$$t = \frac{-v_{y_i} - v_{y_i}}{a}$$
$$= \frac{-35.9\text{ m/s} - 35.9\text{ m/s}}{-9.8\text{ m/s}^2}$$ ← **4 marks**
$$= 7.33\text{ s}$$
$$d_x = v_x \cdot t$$
$$= 77.0\text{ m/s}\cdot 7.33\text{ s}$$
$$= 5.6\times 10^2\text{ m}$$ ← **1 mark**

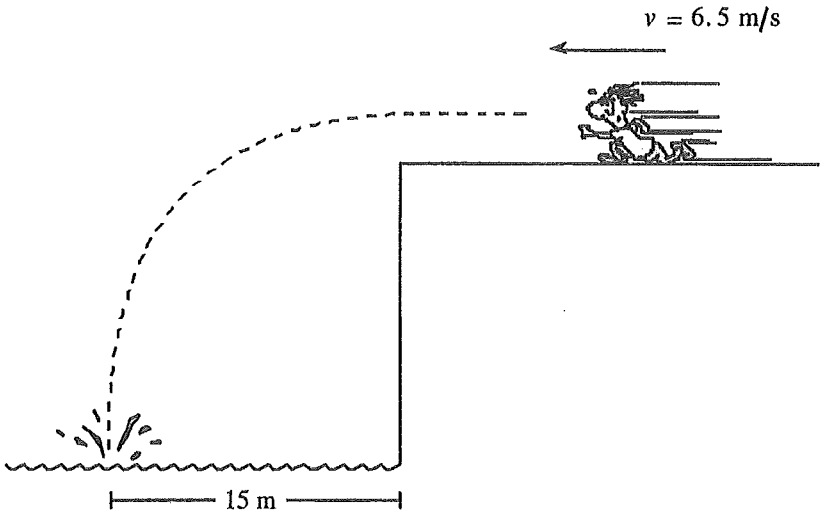
b) Using principles of physics, comment on the horizontal and vertical components of the projectile's velocity and acceleration during the flight. **(4 marks)**

The horizontal component of velocity remains constant. There is no horizontal acceleration (assuming air resistance is negligible). ← **2 marks**

The vertical component of velocity changes continuously during the flight. ← **1 mark**

The vertical acceleration is constant at 9.8 m/s^2, downward, throughout the flight. ← **1 mark**

5. Mike runs horizontally off a cliff at 6.5 m/s and lands in the water 15 m from the base of the cliff.



a) How long does it take Mike to hit the water? **(3 marks)**

$d_H = v_H t$ ← **1 mark**

$t = \dfrac{d_H}{v_H}$

$= \dfrac{15}{6.5}$ ← **1 mark**

$= 2.3\,\text{s}$ ← **1 mark**

b) How high is the cliff? **(4 marks)**

$d = v_0 t + \frac{1}{2} a t^2$ ← **1 mark**

$d = \frac{1}{2}(9.8)(2.3)^2$ ← **2 marks**

$= 26\ \text{m}$ ← **1 mark**

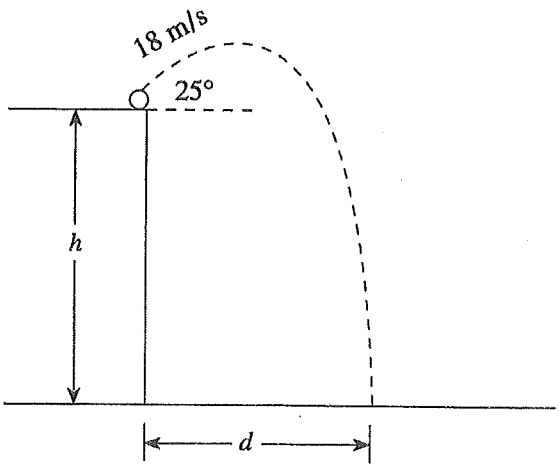
OR

$v_y = v_0 + at = 0 + (9.8)(2.31) = 22.6\ \text{m/s}$

$v^2 = {v_0}^2 + 2ad$

$d = \dfrac{v^2 - {v_0}^2}{2a} = \dfrac{22.6^2 - 0}{2(9.8)} = 26.1$

6. A rock is thrown from a clifftop at 18 m/s, 25° above the horizontal. It lands on the beach 4.2 s later.



a) What is the height h of the cliff? **(4 marks)**

$d = v_0 t + \frac{1}{2} a t^2$ ← **1 mark**

$= (18 \sin 25°)(4.2) + \frac{1}{2}(-9.8)(4.2)^2$ ← **2 marks**

$= -54$ m $\quad (h = 54$ m$)$ ← **1 mark**

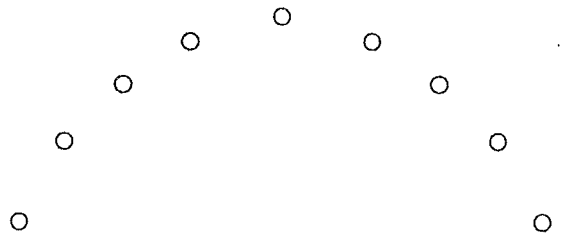
b) How far from the base of the cliff d did the rock land? **(3 marks)**

$d = vt$ ← **1 mark**

$= (18 \cos 25°)(4.2)$ ← **1 mark**

$= 69$ m ← **1 mark**

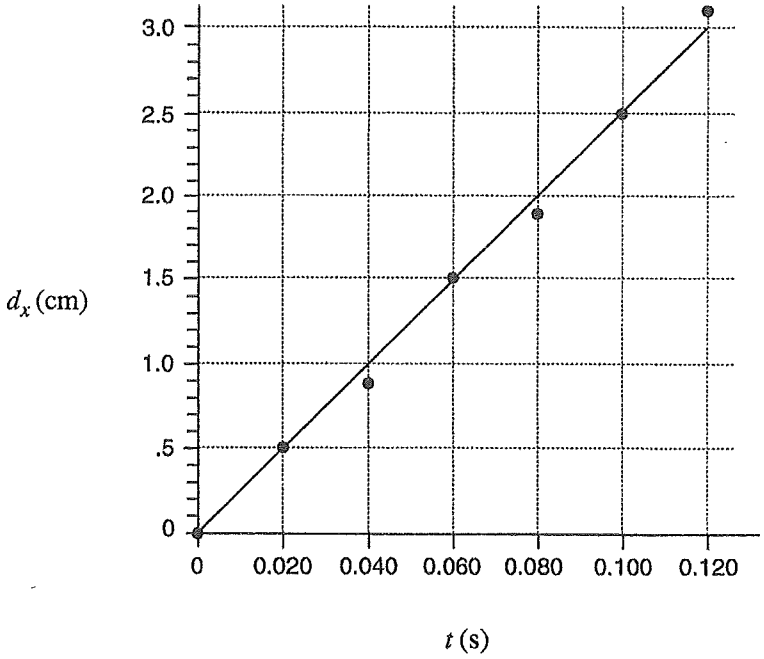
7. A student collects data from the path of a projectile similar to that shown in the diagram.



The student records the following data for horizontal displacement from the initial launch position as a function of time.

d_x (cm)	0.0	0.5	0.9	1.5	1.9	2.5	3.1
t (s)	0.000	0.020	0.040	0.060	0.080	0.100	0.120

a) Plot a graph of d_x vs. t on the graph below. **(2 marks)**



b) Calculate the slope of the line, expressing the answer in appropriate units. **(2 marks)**

$$slope = \frac{2.5 \text{ cm}}{0.1 \text{ s}} = 25 \text{ cm/s}$$

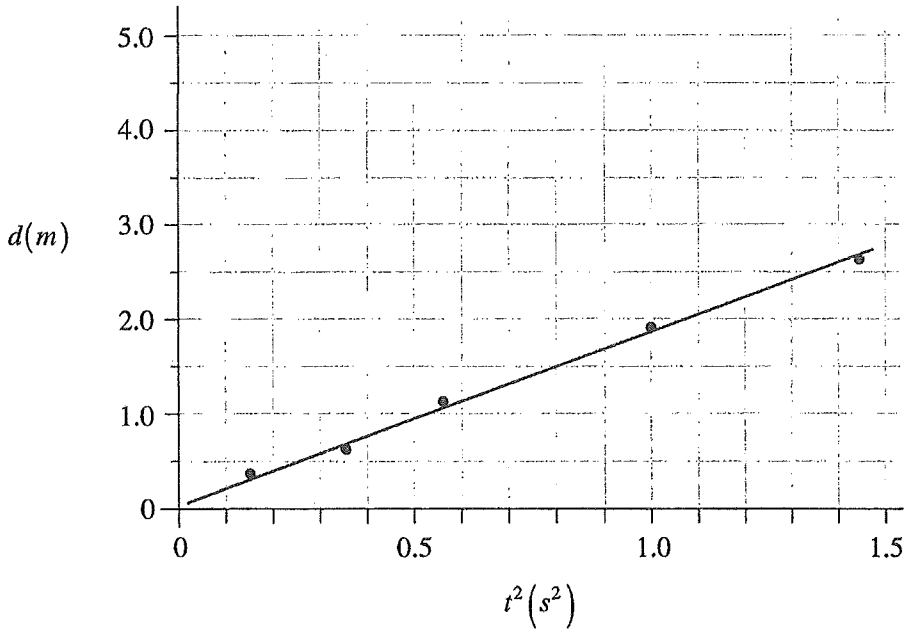
c) Based on this data and graph, make a statement about the behaviour of projectiles. **(1 mark)**

The horizontal speed of projectiles is constant.

8. The first colonists on Mars conduct a physics experiment by dropping a small mass (from rest) and recording its displacement at regular time intervals. This data is shown below.

$d\,(m)$	$t\,(s)$	$t^2\left(s^2\right)$
0.30	0.40	**0.16**
0.60	0.60	**0.36**
1.20	0.80	**0.64**
1.80	1.00	**1.00**
2.70	1.20	**1.44**

a) Plot a graph of displacement versus time squared and draw the best fit straight line.
(2 marks)



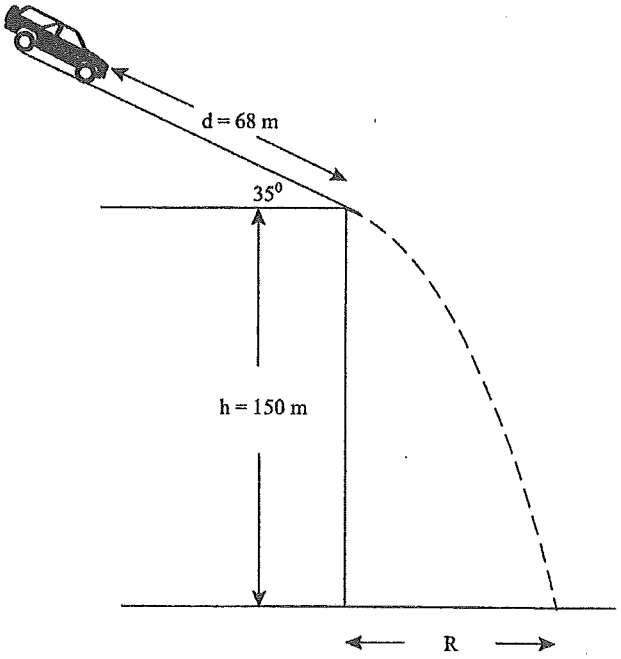
b) Determine the slope of the line. **(2 marks)**

slope $\cong 1.9\ m/s^2$

c) Based on this experiment, what is the acceleration due to gravity on Mars? **(1 mark)**

$\cong 3.8\ m/s^2$

9. A careless driver forgets to set the emergency brakes of their vehicle. The vehicle starts from rest and rolls 68 m along a surface inclined 35^0 to the horizontal, as shown in the diagram below. The cliff is 150 m high.



If friction is negligible, how far (R) from the base of the cliff will the truck hit level ground? **(10 marks)**

$$a = g\sin\theta = (9.8)(\sin 35) = 5.62\frac{m}{s^2}$$ } 1 mark

$$v_f = \sqrt{2ad} = \sqrt{2(5.62)(68)} = 27.7\frac{m}{s}$$ } 1 mark

Velocity Components

$$v_x = v\cos\theta = (27.7)(\cos 35) = 22.7\frac{m}{s}$$ } 1 mark

$$v_y = v\sin\theta = (27.7)(\sin 35) = -15.9\frac{m}{s}\downarrow$$ } 2 marks

$$R = v_x t$$ } 0.5 mark

$$v_{fy} = \pm\sqrt{2ad + v_{iy}^2} = \pm\sqrt{2(-9.8)(-150) + (-15.9)^2} = -56.5\frac{m}{s}$$ } 2.5 marks

$$t = \frac{v_{fy} - v_{iy}}{g} = \frac{-56.5 - (-15.9)}{-9.8} = 4.14s$$ } 1 mark

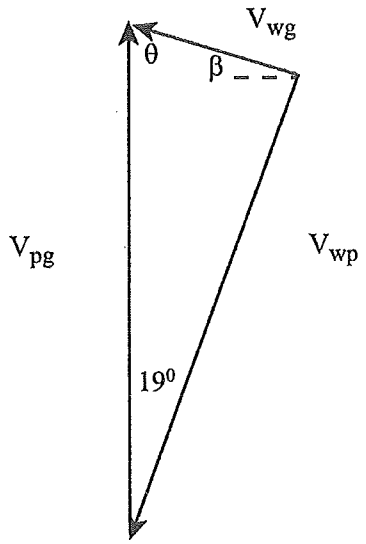
$$R = (22.7)(4.14s) = 94m$$ } 1 mark

10. An aircraft with an airspeed of 250 km/h heads 19^0 east of north. When it encounters a wind, its velocity relative to the ground becomes 260 km/h due north.

a) Write the vector equation for the velocity of the wind relative to the ground. **(1 mark)**

$$V_{wg} = V_{wp} + V_{pg}$$

b) Draw and label the vector diagram which represents the vector equation from part (a). **(3 marks)**



c) What is the velocity of the wind relative to the ground? **(5 marks)**

$$\left.\begin{aligned} V_{wg} &= V_{wp} + V_{pg} \\ V_{wg}^2 &= 250^2 + 260^2 - 2(250)(260)(\cos 19) \\ &= 7183 \\ V_{wg} &= 84.8 \frac{km}{h} \end{aligned}\right\} 3 \text{ marks}$$

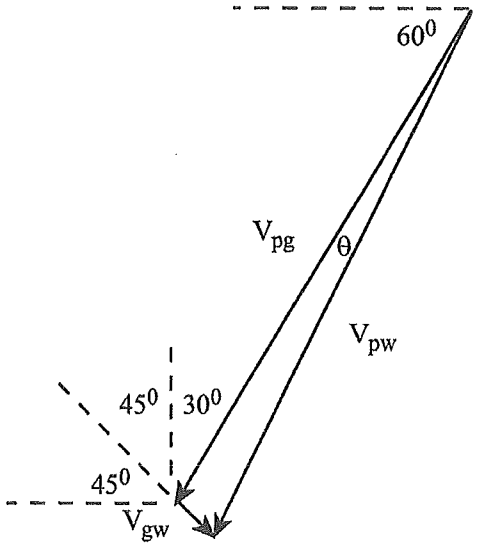
$$\left.\begin{aligned} \frac{\sin\theta}{250} &= \frac{\sin 19}{84.8} \\ \theta &= 73.7^0 \\ \therefore \beta &= 16.3^0 \text{ N of W} \end{aligned}\right\} 2 \text{ marks}$$

11. To reach its destination on time, an aircraft is required to maintain a ground speed of 650 km/h in a direction of 60^0 south of west. A wind is encountered that is blowing at 40 km/h in a direction of 45^0 north of west.

a) Write the vector equation for the velocity of the aircraft relative to the wind. **(1 mark)**

$$V_{pw} = V_{pg} + V_{gw}$$

b) Draw and label the vector diagram which represents the vector equation from part (a). **(3 marks)**

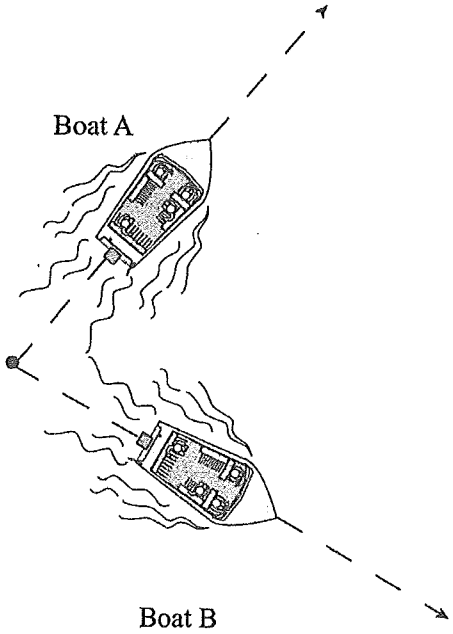


c) What is the velocity of the plane relative to the wind? **(5 marks)**

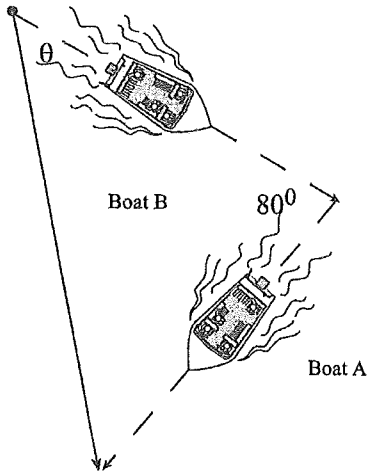
$$\left.\begin{aligned} V_{pw} &= V_{pg} + V_{gw} \\ V_{pw}^2 &= 650^2 + 40^2 - 2(650)(40)(\cos 105) \\ &= 437559 \\ V_{wg} &= 661 \ \frac{km}{h} \end{aligned}\right\} 3 \text{ marks}$$

$$\left.\begin{aligned} \frac{\sin\theta}{40} &= \frac{\sin 105}{661} \\ \theta &= 3.4^0 \\ \therefore \beta &= 63.4^0 \text{ S of W} \end{aligned}\right\} 2 \text{ marks}$$

12. Boats A and B both leave the same point at the same time. Boat A has a speed of 25 km/h with a heading of 50^0 north of east, while Boat B has a speed of 35 km/h with a heading of 30^0 south of east.



a) What is the velocity of Boat B relative to Boat A? **(5 marks)**



$$V_{BA} = V_{BW} + V_{WA}$$
$$V_{BA}^2 = 35^2 + 25^2 - 2(35)(25)(\cos 80)$$
$$V_{BA}^2 = 1546$$
$$V_{BA} = 39.3\frac{km}{h}$$

} 3 marks

$$\frac{\sin\theta}{25} = \frac{\sin 80}{39.3}$$
$$\theta = 38.8^0$$
$$\therefore \beta = 68.8^0 \text{ S of E}$$

} 2 marks

b) How far apart are the two boats after 2.0 hours? **(2 marks)**

$$d = vt$$
$$= (39.3)(2.0)$$
$$= 78.6km$$

} 2 marks