PART A

FOR EACH OF THE FOLLOWING QUESTIONS IN PART A, ENTER THE MOST APPROPRIATE RESPONSE ON THE OMR SHEET.

C

A1. In the following equations the units of the quantities are a (m/s^2), v (m/s), v_0 (m/s), t (s), x (m). Which one of the following equations is *dimensionally* **incorrect**?

(A) $v - at = v_0$ (B) $a^2t^2 = ax$ (C) $at = x$ (D) $x = v^2/a$ (E) $x/t = (v_0 + v)$

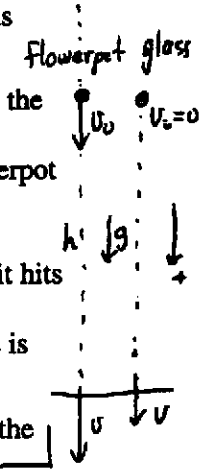
D

A2. A rock is thrown directly upward. Neglecting the effects of air resistance, what is the instantaneous acceleration of the rock at the highest point in its flight?

(A) It is zero. (B) It is less than g downward. (C) It is greater than g downward.
(D) It is g downward. (E) It is less than g upward.

A

A3. A flowerpot falls off the edge of a fifth-floor window. Just as it passes the third-floor window, someone drops a glass of water from that window. Which one of the following statements is true? (Neglect air resistance.)

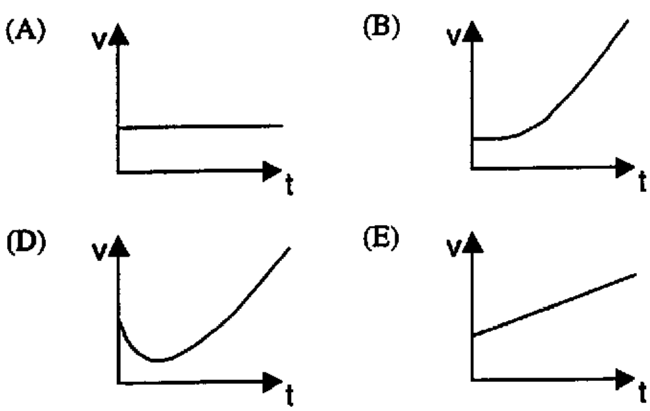


(A) The flowerpot hits the ground first with a higher speed than the glass has when it hits the ground.
(B) The flowerpot hits the ground at the same time as the glass, but the speed of the flowerpot is greater that that of the glass.
(C) The flowerpot and the glass hit the ground at the same time and with the same speed.
(D) The glass hits the ground before the flowerpot, but the glass has a lower speed when it hits than the flowerpot when it hits.
(E) The flowerpot hits the ground at the same time as the glass, but the speed of the glass is greater than the speed of the flowerpot.

At ground:
flowerpot
$v^2 = v_0^2 + 2gh$
$h = v_0 t + \frac{1}{2}gt^2$
glass
$v^2 = 2gh$
$h = \frac{1}{2}gt^2$

E

A4. Which one of the following velocity verses time graphs represents an object moving along the x-axis with a constant non-zero positive acceleration?



a = slope of v vs. t graph.

A

A5. Vector **A** has horizontal and vertical components of 1.5 m and 2.0 m respectively. Vector **B** has horizontal and vertical components of –1.5 m and –2.0 m respectively. The vector **C** = **A** + **B** has magnitude

(A) zero (B) 7.0 m (C) 4.0 m (D) 3.0 m (E) 2.5 m

$C_x = A_x + B_x = 0$, $C_y = A_y + B_y = 0$ $\Rightarrow \vec{C} = 0$

continued on page 3 ...

A6. A brick is dropped from rest and a rock is thrown horizontally. Both objects are released from the top of a vertical cliff at the same instant. Compare the time it takes each object to reach the level ground at the base of the cliff. (Neglect air resistance.)

E

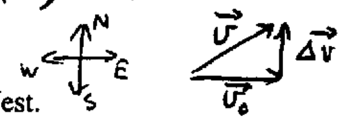
$v_{0y} = 0$ for both
∴ vertical motion the same for both.

(A) The brick reaches the ground first.
(B) The rock reaches the ground first.
(C) Which object reaches the ground first depends on the speed with which the rock is thrown. If the rock is thrown faster than a certain value the brick will reach the ground first.
(D) Which object reaches the ground first depends on the speed with which the rock is thrown. If the rock is thrown faster than a certain value the rock will reach the ground first.
(E) Both objects reach the ground at the same time.

A7. An object is moving in the Eastward direction at constant velocity. A net force directed Northward acts on the object for 5.0 s. At the end of the 5.0 s period, the net force drops to zero. Which one of the following statements is **necessarily** true?

B

$\vec{F}$ north ⇒ $\vec{a}$ north ⇒ $\Delta\vec{v}$ north



(A) The object will be moving Eastward when the force drops to zero.
(B) The final velocity of the object will be directed North of East.
(C) The change in the velocity of the object will be directed North of West.
(D) The direction of the object's acceleration depends on how fast the object was initially moving.
(E) The magnitude of the object's acceleration depends on how fast the object was initially moving.

A8. The weight of an object of mass m is W when the object is on the Earth's surface. The object is now taken to a height h above the Earth's surface where h equals the radius of the Earth. The Earth's gravitational force on the object is now

C

$W = \frac{GM_E m}{h^2}$

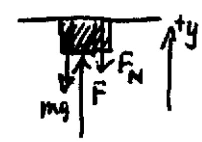
$W' = \frac{GM_E m}{(2h)^2}$

$\therefore W' = W/4$

(A) 0 (B) $W/2$ (C) $W/4$ (D) $2W$ (E) $4W$

A9. A painter holds a paint brush, of mass m, against the ceiling by applying a vertical force of magnitude F. The magnitude of the normal force of the ceiling on the brush is

C



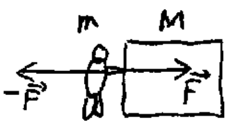
(A) $F+m$ (B) $F-m$ (C) $F-mg$ (D) $F+mg$ (E) 0

$\Sigma F_y = F - mg - F_N = 0 \Rightarrow F_N = F - mg$

A10. A space-walking astronaut (with mass m) and a spacecraft (with mass $M > m$) are in deep space. The astronaut pushes on the spacecraft with a force of magnitude F. Which one of the following statements is correct?

A

(A) The magnitude of the force of the astronaut on the spacecraft equals the magnitude of the force of the spacecraft on the astronaut.
(B) The magnitude of the force of the astronaut on the spacecraft is less than the magnitude of the force of the spacecraft on the astronaut.
(C) The magnitude of the force of the astronaut on the spacecraft is greater than the magnitude of the force of the spacecraft on the astronaut.
(D) The magnitude of the final velocity of the astronaut equals the magnitude of the final velocity of the spacecraft.
(E) The magnitude of the acceleration of the astronaut equals the magnitude of the acceleration of the spacecraft.



Newtons 3rd Law: $\vec{F}_m = -\vec{F}$

Newtons 2nd Law

$F_m = m a_m$ $F = M a_M$ $\therefore a_m \neq a_M$

continued on page 4 ...

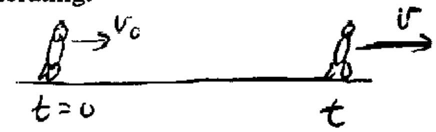
Student No.: ____________________

PART B

FOR EACH OF THE FOLLOWING PROBLEMS, B1 TO B5, ON PAGES 4 TO 6, WORK OUT THE SOLUTION IN THE SPACE PROVIDED AND ENTER YOUR ANSWERS ON PAGE 6.

ONLY THE ANSWERS WILL BE MARKED. THE SOLUTIONS WILL NOT BE MARKED.

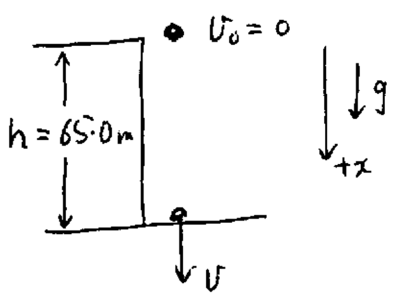
B1. A runner is moving at a velocity of 3.36 m/s. He accelerates at 0.670 m/s^2 and soon reaches a velocity of 5.92 m/s. Calculate the time during which he was accelerating.



$$v = v_0 + at$$

$$\Rightarrow t = \frac{v - v_0}{a} = \frac{5.92\ \text{m/s} - 3.36\ \text{m/s}}{0.670\ \text{m/s}^2} = 3.82\ \text{s}$$

B2. A rock is dropped from rest from the top of a 65.0 m tall building. Calculate the speed of the rock just before it hits the ground. (Ignore air resistance.)



$v_0 = 0$
v ?
$a = g$
$x = h = 65.0$ m
t ?

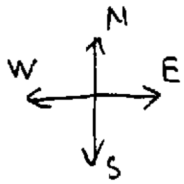
$$v^2 = v_0^2 + 2ax$$

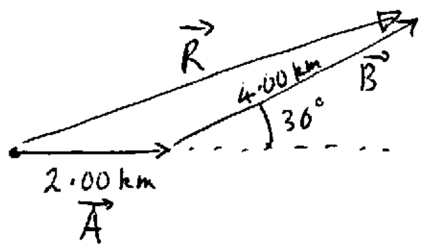
$$\Rightarrow v^2 = 0 + 2gh$$

$$v = \sqrt{2gh} = \sqrt{2(9.80\ \text{m/s}^2)(65.0\ \text{m})} = 35.7\ \text{m/s}$$

continued on page 5 ...

B3. A woman walks 2.00 km due East and then walks 4.00 km in the direction 30.0° North of East. Calculate the magnitude of her displacement from her starting point.





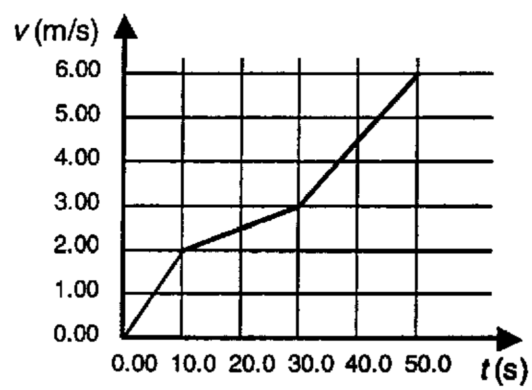
$$\vec{R} = \vec{A} + \vec{B}$$

$$R_x = A_x + B_x$$
$$= 2.00\,\text{km} + 4.00\,\text{km} \cos 30°$$
$$= 5.464\,\text{km}$$

$$R_y = A_y + B_y$$
$$= 0 + 4.00\,\text{km} \sin 30°$$
$$= 2.000\,\text{km}$$

$$R = \sqrt{R_x^2 + R_y^2}$$
$$= \sqrt{(5.464\,\text{km})^2 + (2.000\,\text{km})^2}$$
$$= 5.82\,\text{km}$$

B4. The velocity of a car changes as shown in the figure. Calculate the average acceleration of the car in the time interval from $t = 0$ to $t = 50.0$ s.



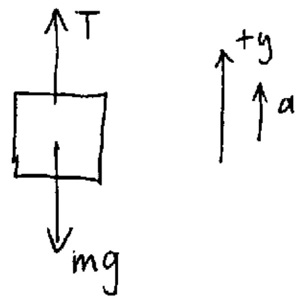
$$\bar{a} = \frac{v - v_0}{t - t_0}$$
$$= \frac{6.00\,\text{m/s} - 0}{50.0\,\text{s} - 0}$$
$$= 0.120\,\text{m/s}^2$$

continued on page 6 ...

Student No.: ____________________

B5. A cable causes an elevator car of mass 1.20×10^3 kg to have an upward acceleration of 1.50 m/s^2. Calculate the tension in the cable. (Ignore frictional effects.)

FBD of forces on elevator car



$$\Sigma F_y = m a_y$$

$$T - mg = ma$$

$$\Rightarrow T = ma + mg$$

$$= m(a + g)$$

$$= 1.20 \times 10^3 \text{ kg} \left(1.50 \text{ m/s}^2 + 9.80 \text{ m/s}^2\right)$$

$$= 1.36 \times 10^4 \text{ N}$$

ANSWERS FOR PART B

ENTER THE ANSWERS FOR THE PART B PROBLEMS IN THE BOXES BELOW.

THE ANSWERS MUST CONTAIN THREE SIGNIFICANT FIGURES AND THE UNITS MUST BE GIVEN.

ONLY THE ANSWERS WILL BE MARKED. THE SOLUTIONS WILL NOT BE MARKED.

B1	3.82 s
B2	35.7 m/s
B3	5.82 km
B4	0.120 m/s^2
B5	1.36×10^4 N

continued on page 7 ...

Student No.: ______________________

PART C

IN EACH OF THE PART C QUESTIONS ON THE FOLLOWING PAGES, GIVE THE COMPLETE SOLUTION AND ENTER THE FINAL ANSWER IN THE BOX PROVIDED.

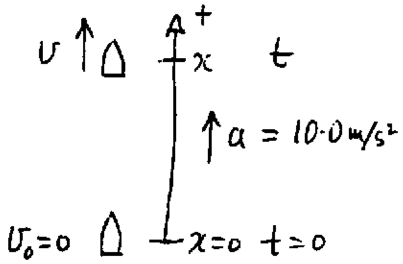
THE ANSWERS MUST CONTAIN THREE SIGNIFICANT FIGURES AND THE UNITS MUST BE GIVEN.

<u>SHOW YOUR WORK</u> – NO CREDIT WILL BE GIVEN FOR ANSWERS ONLY. EQUATIONS NOT PROVIDED ON THE FORMULAE SHEET MUST BE DERIVED.

USE THE BACK OF THE PREVIOUS PAGE FOR YOUR ROUGH WORK.

C1. A rocket is launched vertically up from rest and accelerates upward at 10.0 m/s^2 for 5.00 s during the rocket burn. After the burn ceases the rocket comes under the influence of gravity alone. (Ignore air resistance in this problem.)

(a) Calculate the height of the rocket when the burn ceases.



$x = v_0 t + \frac{1}{2}at^2$

$= \frac{1}{2}at^2$

$= \frac{1}{2}(10.0\ \text{m/s}^2)(5.00\ \text{s})^2$

$= 125\ \text{m}$

Answer
125 m

(b) Calculate the velocity of the rocket at the time when the burn ceases.

$v = v_0 + at$

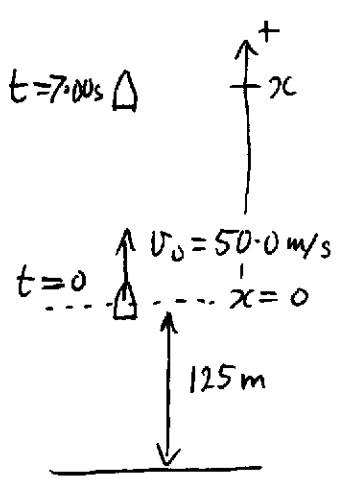
$= at$

$= (10.0\ \text{m/s}^2)(5.00\ \text{s})$

$= 50.0\ \text{m/s}$

Answer
50.0 m/s

(c) Calculate the height of the rocket above the launch pad 12.0 s after lift-off.



In this part let $t = 0$ when burn ceases and $x = 0$

$\therefore$ 12.0 s after lift-off is

$t = 12.0\ \text{s} - 5.00\ \text{s} = 7.00\ \text{s}$

$a_y = -g$ now (gravity only)

$x = v_0 t + \frac{1}{2}at^2$

$= v_0 t - \frac{1}{2}gt^2$

$= (50.0\ \text{m/s})(7.00\ \text{s}) - \frac{1}{2}(9.80\ \text{m/s}^2)(7.00\ \text{s})^2$

$= 110\ \text{m}$

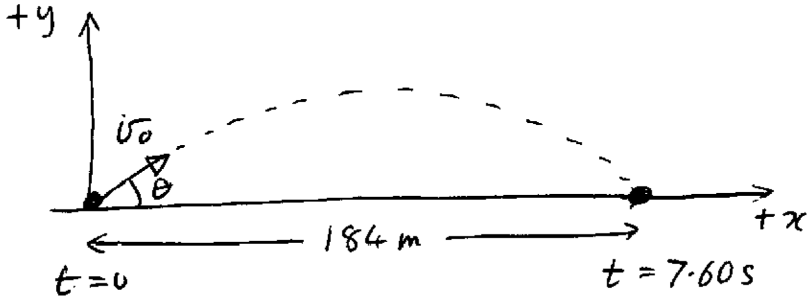
$\therefore$ height $= 125\ \text{m} + 110\ \text{m} = 235\ \text{m}$

Answer
235 m

continued on page 8 ...

C2. A football is kicked from the ground so that it travels through the air and lands on the horizontal level ground at a point that is a distance of 184 m from where it was kicked. The ball was in the air for a time of 7.60 s. Ignoring air resistance, calculate the initial velocity of the ball just after it was kicked. Express the direction of the velocity as the angle (in degrees) above the horizontal.

Magnitude:	44.4 m/s
Direction:	57.0 °

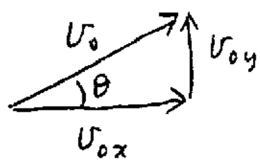


x: v_{ox} ?
$t = 7.60\,s$
$x = 184\,m$
$a_x = 0$
$v_x = v_{ox}$

y: v_{oy} ?
$t = 7.60\,s$
$y = 0$
$a_y = -g$
$v_y = ?$

$$x = v_{ox}t$$
$$\Rightarrow v_{ox} = \frac{x}{t} = \frac{184\,m}{7.60\,s} = 24.21\ m/s$$

$$y = v_{oy}t + \tfrac{1}{2}a_y t^2$$
$$\Rightarrow 0 = v_{oy}t - \tfrac{1}{2}gt^2$$
$$\Rightarrow v_{oy}t = \tfrac{1}{2}gt^2$$
$$\Rightarrow v_{oy} = \tfrac{1}{2}gt = \tfrac{1}{2}(9.80\,m/s^2)(7.60\,s) = 37.24\ m/s$$



$$v = \sqrt{v_{ox}^2 + v_{oy}^2} = \sqrt{(24.21\,m/s)^2 + (37.24\,m/s)^2} = 44.4\ m/s$$

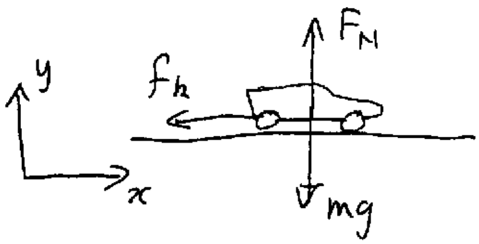
$$\tan\theta = \frac{v_{oy}}{v_{ox}} = \frac{37.24\,m/s}{24.21\,m/s} = 1.538$$

$$\Rightarrow \theta = 57.0^\circ$$

continued on page 9 ...

C3. An automobile's wheels are locked as it slides to a stop from an initial speed of 30.0 m/s. If the coefficient of kinetic friction between the tires and the road is 0.200 and the road is horizontal, calculate the time required for the car to stop.

15.3 s



FBD of forces on car as it is sliding.

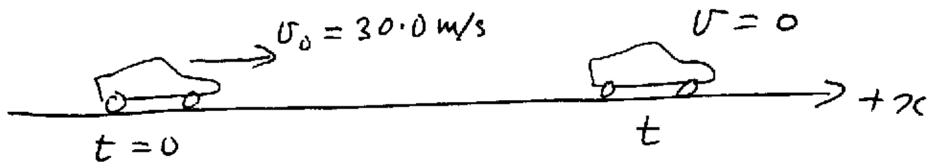
$$\Sigma F_x = m a_x \quad\Rightarrow\quad -f_k = m a_x$$

$$\Sigma F_y = F_N - mg = m a_y \quad\Rightarrow\quad F_N - mg = 0 \quad\Rightarrow\quad F_N = mg$$

Now $f_k = \mu_k F_N = \mu_k mg$

$$\Rightarrow -\mu_k mg = m a_x$$

$$\Rightarrow a_x = -\mu_k g = -(0.200)(9.80\ \text{m/s}^2) = -1.960\ \text{m/s}^2$$



$$v = v_0 + a_x t$$

$$\Rightarrow t = \frac{v - v_0}{a_x} = \frac{0 - 30.0\ \text{m/s}}{-1.960\ \text{m/s}^2} = 15.3\ \text{s}$$

END OF EXAMINATION