2012

# Physics – 553-504

## Cycle 2, Year 3
## (Secondary 5)

# Theory Examination

Question Booklet

Time: 3 hours

## INSTRUCTIONS

1. Fill in the required information on the cover page of the ***Answer Booklet***.

2. Write your answers in the ***Answer Booklet***, showing all work.

3. This examination is made up of 21 questions and is worth 90 marks.

4. The rules of significant figures should be applied to all final statements. A mark will be allocated for the correct use of significant figures for Questions 11, 16 and 19.

5. You may use drawing instruments and a scientific calculator without a graphic display.

6. You may refer to the Table of Trigonometric Ratios and lists of Formulas and Quantities included in the Appendix of the ***Question Booklet***. The use of any other reference material is strictly forbidden.

**Note:** **Figures are not necessarily drawn to scale.**

TIME: 3 hours

# Part A
## Multiple Choice Questions

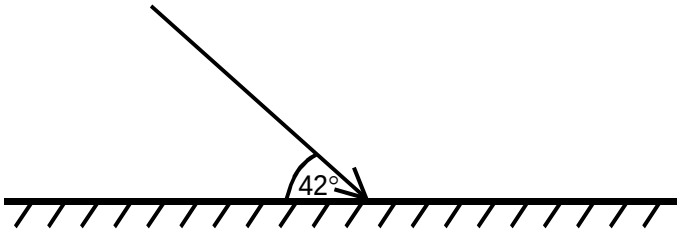
**Questions 1 to 10**

Answer all questions in the ***Answer Booklet***.

Shade the letter that corresponds to your answer in the ***Answer Booklet***.

## Question 1

During a physics laboratory investigation, students study the angles of reflection on plane mirrors. Jessica directs a light ray at a 42° angle to the surface of the mirror, as shown in the diagram below.




**What is the angle of reflection?**

A) 42°

B) 48°

C) 84°

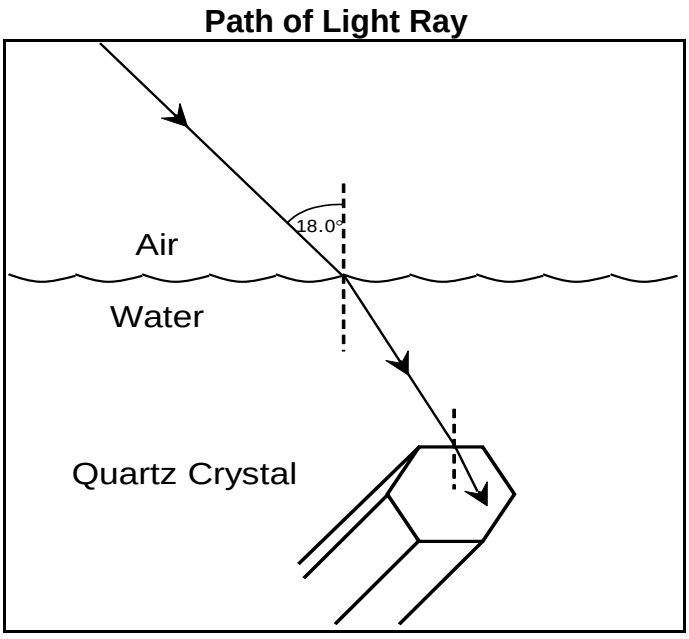
D) 90°

## Question 2

Geologists, Marie-Pier and Jayson, are exploring an old quarry in Maine that is now filled with water. Jayson decides to scuba dive, while Marie-Pier shines a light into the water with an angle of incidence equal to 18.0°. These rays of light travel through air, water and then into a quartz crystal whose top surface is parallel to the surface of the water.

(Diagram not drawn to scale.)

| Substance | Index of Refraction |
|---|---|
| Air | 1.00 |
| Water | 1.33 |
| Quartz Crystal | 1.46 |




**What is the angle of refraction in the quartz crystal?**

A) 72.0°

B) 18.0°

C) 13.4°

D) 12.2°

## Question 3

During a laboratory investigation on the properties of light, students study the phenomena of total internal reflection.

**Which of the statements below best describes total internal reflection?**

A) Total internal reflection occurs when the angle of incidence is greater than the critical angle.

B) Total internal reflection occurs when the angle of incidence is equal to the critical angle.

C) Total internal reflection occurs when the angle of incidence is less than the critical angle.

D) Total internal reflection occurs when the angle of refraction is equal to the critical angle.

## Question 4

Friends go shopping downtown. They are initially 40 m west of the library. They have lunch at a restaurant 100 m east of the library. After lunch, knowing that their physics teacher has a sweet tooth, they go to a bakery that is 45 m west of the restaurant to buy cookies.

**What is their total displacement?**

A) 55 m [E]

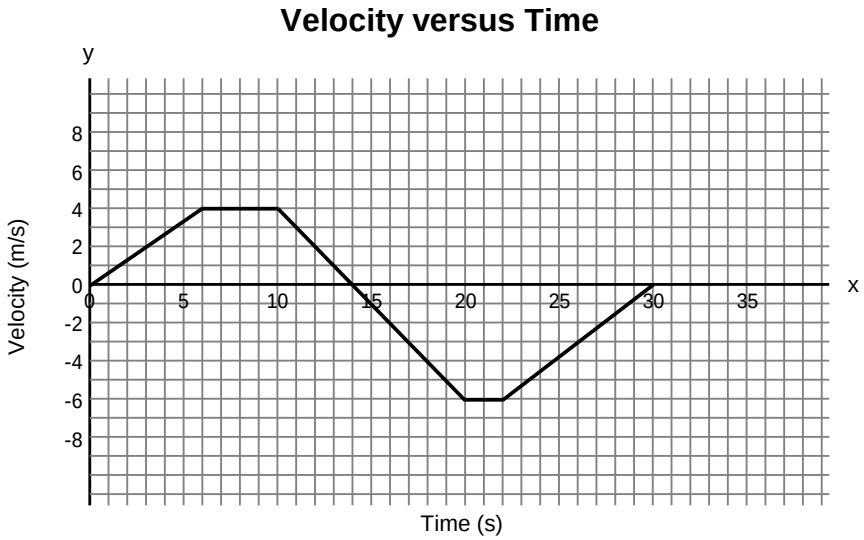
B) 95 m [E]

C) 140 m [E]

D) 185 m [E]

## Question 5

The graph below illustrates the motion of a car over a 30 second time interval.




**During which time interval is the car moving backwards and with increasing speed?**

A) 22 s to 30 s

B) 14 s to 20 s

C) 10 s to 20 s

D) 0 s to 6 s

## Question 6

Logan throws a measuring tape straight upwards with a velocity of 12 m/s to his father who is working on the roof of their house. The father catches the measuring tape 5.3 m above its initial starting position. (Neglect air resistance.)

**What is the velocity of the measuring tape when caught by the father?**

A) 6.3 m/s

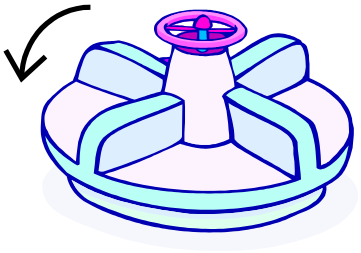
B) 11 m/s

C) 16 m/s

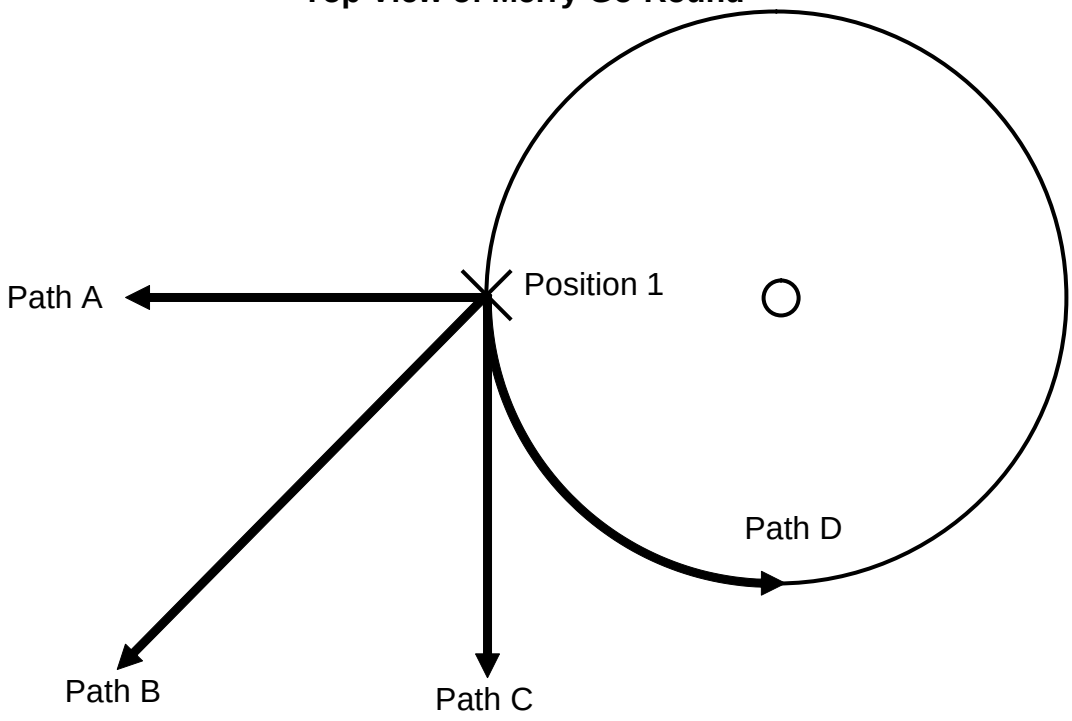
D) 40 m/s

## Question 7

Genevieve is standing on a playground merry-go-round that is rotating counter-clockwise. She accidentally drops a coin while she is at position 1, as indicated in the diagram below.



**Top View of Merry-Go-Round**




**Which path will the coin take?**

A) Path A

B) Path B

C) Path C

D) Path D

## Question 8

Sanjay and Asha are playing outside. Asha sits on the sled, while Sanjay pulls the sled's handle at an angle of 34° to the horizontal. There is a 3.7 N frictional force acting on the sled. As a result, the sled experiences a net horizontal force of 25.5 N.


**What is the applied force?**

A) 26 N

B) 29 N

C) 35 N

D) 39 N

## Question 9

The Apollo 11 mission's LM (Lunar Module) was the first vehicle to transport people to the moon. The LM's mass on Earth is 15 000 kg. The astronauts confirmed that the moon has a gravitational acceleration of 1.6 $m/s^2$.

**What is the weight of the LM on the surface of the moon?**

A) 1 500 N

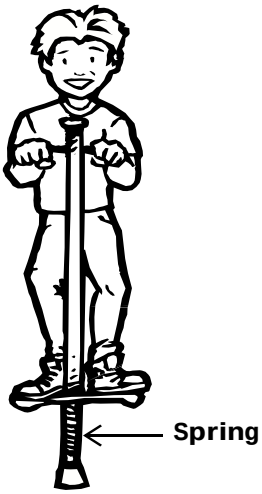
B) 9 400 N

C) 15 000 N

D) 24 000 N

## Question 10

Mark has a mass of 25 kg. He stands on a pogo stick and the spring length changes from an initial length of 21.0 cm to a final length of 8.0 cm.




**What is the force constant of the pogo stick's spring?**

A) $1.9 \times 10^1$ N/m

B) $3.1 \times 10^2$ N/m

C) $1.9 \times 10^3$ N/m

D) $3.1 \times 10^3$ N/m

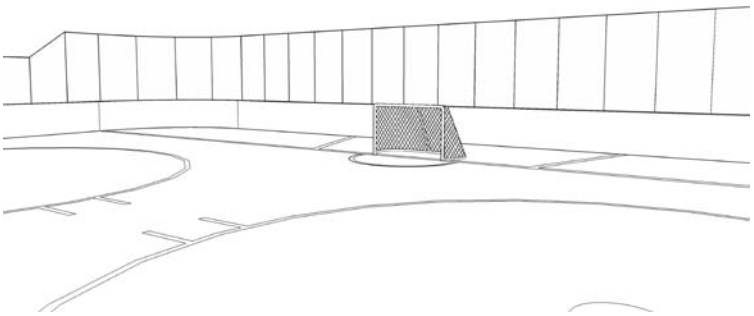
# Part B
## Constructed Response Questions

**Questions 11 to 21**

Answer all these questions in the ***Answer Booklet***.

## Question 11

Plexiglas® is commonly used in hockey arenas to protect spectators from the game on the ice. The Plexiglas® has a thickness of 1.5 cm and has an index of refraction of 1.51.

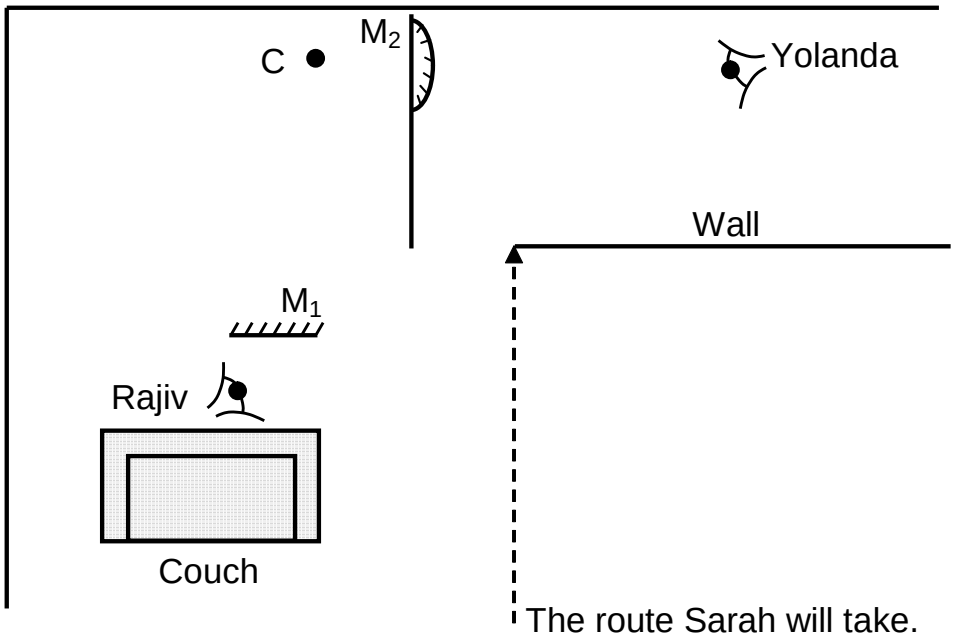


**How much time will it take for light to pass from one side of the Plexiglas® to the other?**

***(Significant figures will be marked.)***

## Question 12

Sarah's friends have planned a surprise birthday party for her. Rajiv is hiding behind a couch. He has a plane mirror ($M_1$) in his hand. Yolanda is hiding in the hallway where there is a convex mirror ($M_2$) on the wall. (C is the centre of curvature.)



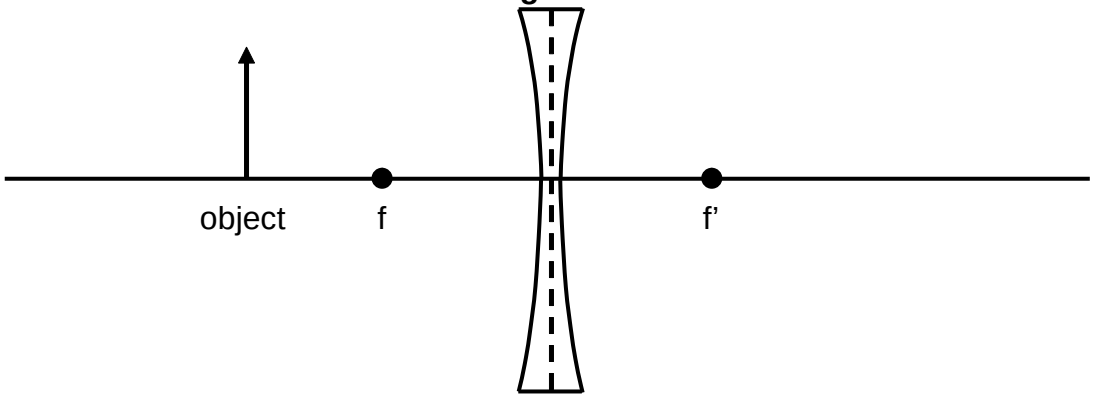

**Who will see Sarah first, Rajiv or Yolanda?**

**Provide a complete ray diagram in your *Answer Booklet*.**

## Question 13

An object is placed in front of a lens as illustrated below.

**Scale Diagram of Lens**




**Complete the ray diagram to locate the image that will be produced by this lens.**

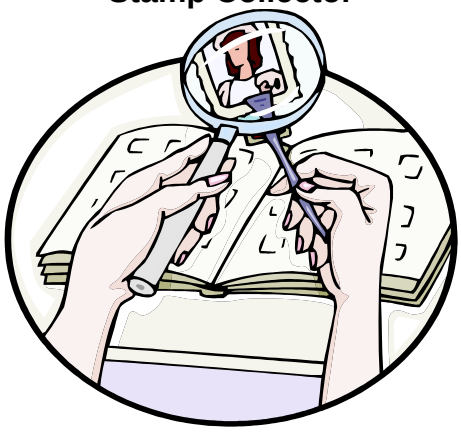
**Provide a complete ray diagram in your *Answer Booklet*.**

## Question 14

Julie is a stamp collector. Before purchasing a stamp for her collection, she inspects it for flaws using a magnifying glass. Her magnifying glass has a converging lens with a 15 cm focal length.

The upright image is 3 times the size of the stamp.

**Stamp Collector**

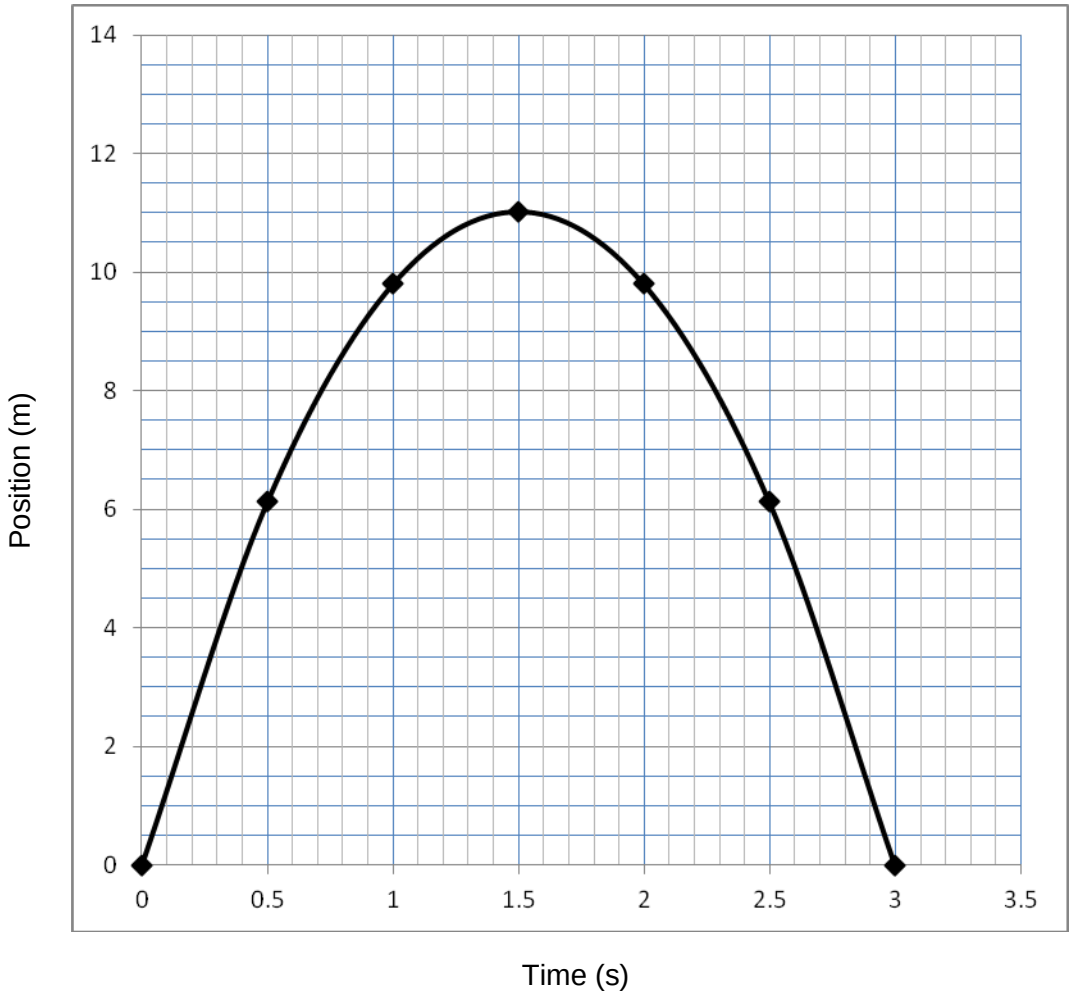


**How far is the stamp from the magnifying glass?**

## Question 15

A ball is thrown upwards. A graph illustrating its motion is shown below.

**Position (m) versus Time (s)**

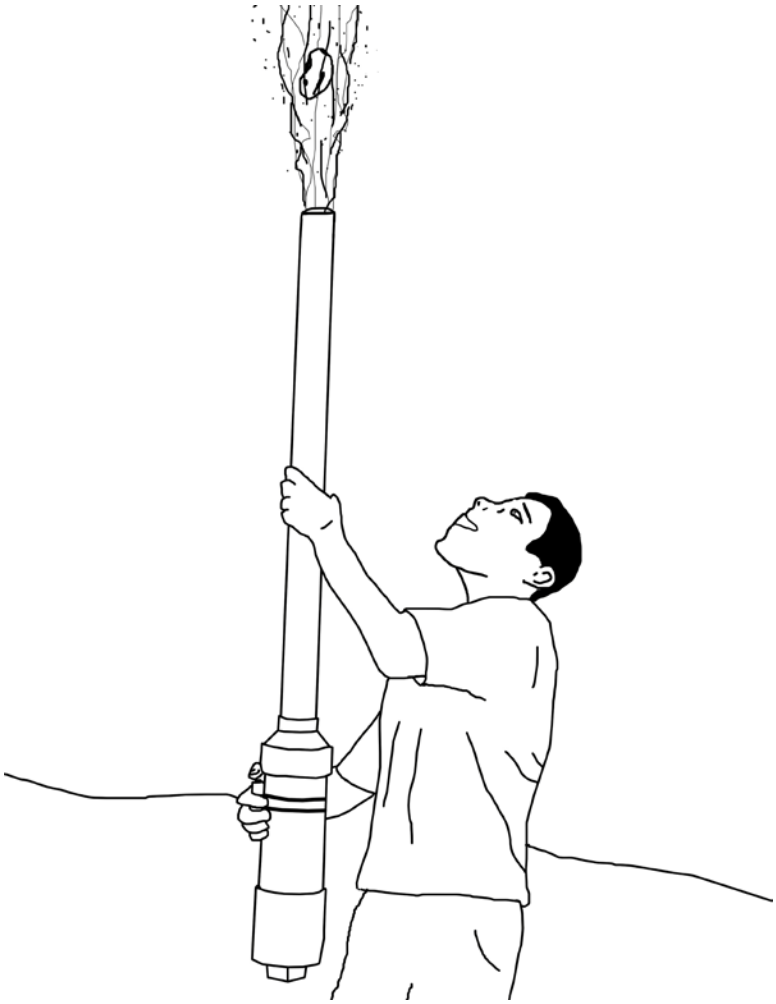



**What is the instantaneous speed of the ball at 0.75 seconds?**

## Question 16

A potato is launched vertically from a potato cannon. The initial velocity at it leaves the cannon is 18 m/s upwards. (Neglect friction.)

**Potato Cannon**



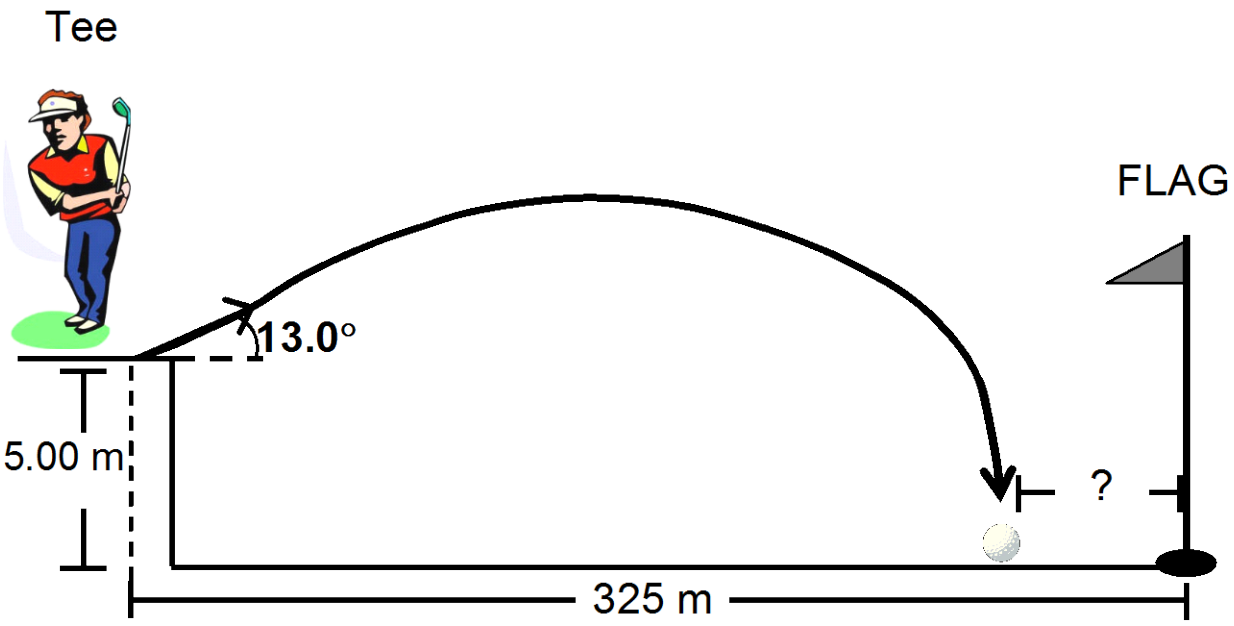
**What time(s) will the potato be at 14.5 m above its initial position?**

***(Significant figures will be marked.)***

## Question 17

Phil is a famous pro golfer. On the 18th hole he hit the ball towards the flag with an initial velocity of 80.0 m/s and at an angle of 13.0° above the horizontal. The tee is 5.00 m above the fairway, where the ball landed. The flag is 325 m away from where Phil hit the ball. (Neglect air resistance.)

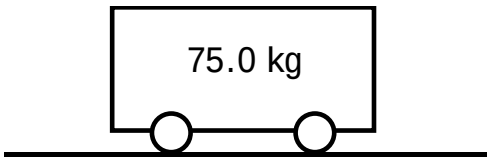
(Diagram not to scale)




**How far from the flag did the ball land? (Neglect bounce.)**

## Question 18

A worker pushes a 75.0 kg cart along a flat surface. The applied force is 100 N and the frictional force is 15.0 N.




**Draw a free body diagram. Indicate the magnitude of each force on the diagram.**

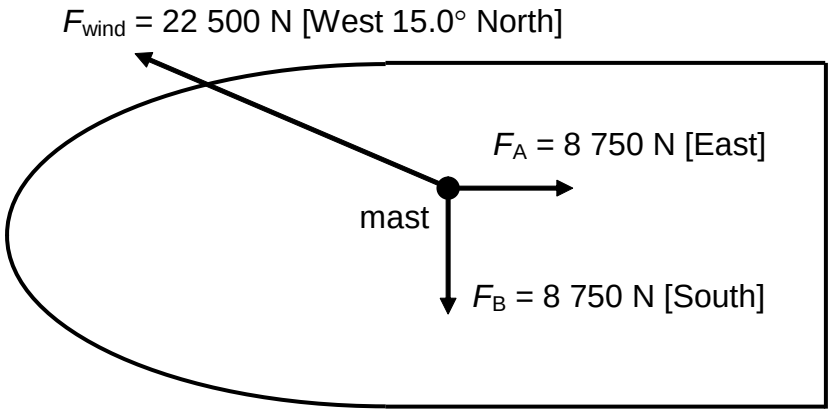
## Question 19

Pirate Captain Vectorbeard is sailing the sea in search of treasure. A storm is approaching Captain Vectorbeard's ship. The main mast of the ship is already secured with two cables that exert the forces on the mast ($F_A$ = 8 750 N [East] and $F_B$ = 8 750 N [South]). The winds will exert 22 500 N [West 15.0° North] upon the ship. Captain Vectorbeard has only one spare cable, which he must use to balance the other forces on the mast making the net force zero.

(Diagram not to scale)

(All forces are to be considered horizontal.)

**Top View of Vector Diagram**

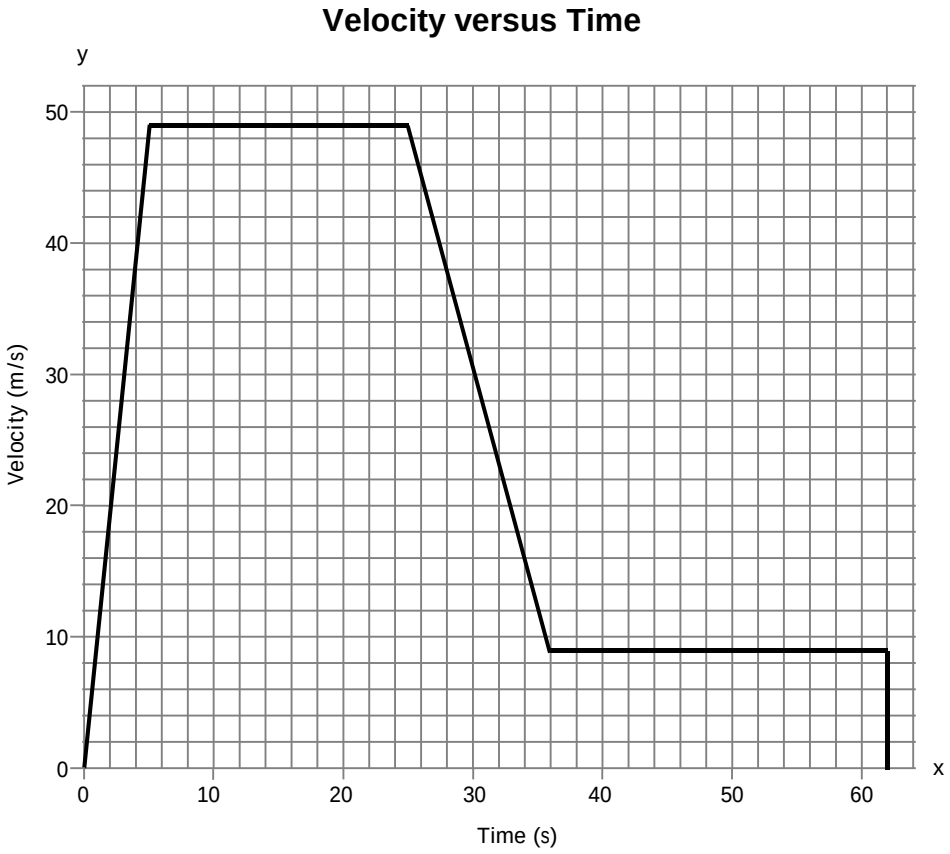



**What force does Captain Vectorbeard need to apply to the mast in order to keep all of the forces upon the mast into equilibrium?**

***(Significant figures will be marked.)***

## Question 20

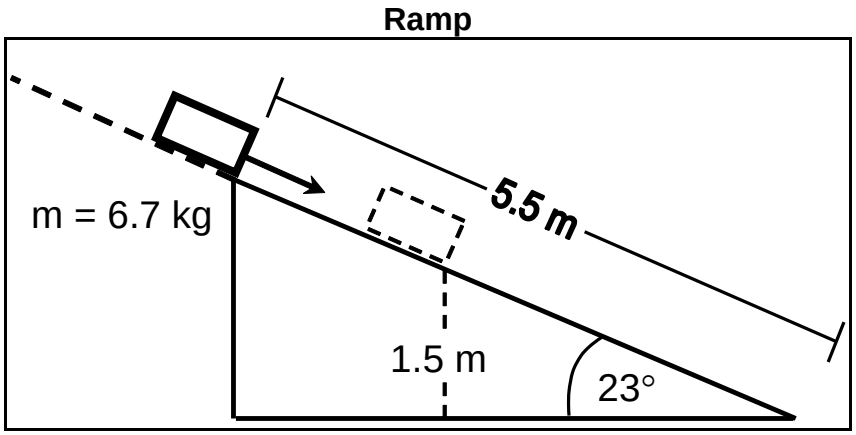
A skydiver jumps from an airplane and is free-falling. At 5 seconds, she reaches her terminal velocity. At 25 seconds, she opens her parachute, which causes her to decelerate until she reaches a much slower terminal velocity at 36 seconds. At 62 seconds, she lands safely on the ground.




**What was the height of the airplane when she started her jump?**

## Question 21

A 6.7 kg object initially starts from rest at the top of a ramp. The length of the ramp is 5.5 m and forms an angle of 23° above the horizontal. When the object reaches a height of 1.5 m, it has a speed of 3.0 m/s.




**What is the force of friction?**

**Appendix 1**

## Table of Trigonometric Ratios

| Angle | sin | Cos | tan | Angle | sin | Cos | tan |
|---|---|---|---|---|---|---|---|
| **0°** | 0.0000 | 1.0000 | 0.0000 | **45°** | 0.7071 | 0.7071 | 1.0000 |
| **1°** | 0.0175 | 0.9998 | 0.0175 | **46°** | 0.7193 | 0.6947 | 1.0355 |
| **2°** | 0.0349 | 0.9994 | 0.0349 | **47°** | 0.7314 | 0.6820 | 1.0724 |
| **3°** | 0.0523 | 0.9986 | 0.0524 | **48°** | 0.7431 | 0.6691 | 1.1106 |
| **4°** | 0.0698 | 0.9976 | 0.0699 | **49°** | 0.7547 | 0.6561 | 1.1504 |
| **5°** | 0.0872 | 0.9962 | 0.0875 | **50°** | 0.7660 | 0.6428 | 1.1918 |
| **6°** | 0.1045 | 0.9945 | 0.1051 | **51°** | 0.7771 | 0.6293 | 1.2349 |
| **7°** | 0.1219 | 0.9925 | 0.1228 | **52°** | 0.7880 | 0.6157 | 1.2799 |
| **8°** | 0.1392 | 0.9903 | 0.1405 | **53°** | 0.7986 | 0.6018 | 1.3270 |
| **9°** | 0.1564 | 0.9877 | 0.1584 | **54°** | 0.8090 | 0.5878 | 1.3764 |
| **10°** | 0.1736 | 0.9848 | 0.1763 | **55°** | 0.8192 | 0.5736 | 1.4281 |
| **11°** | 0.1908 | 0.9816 | 0.1944 | **56°** | 0.8290 | 0.5592 | 1.4326 |
| **12°** | 0.2079 | 0.9781 | 0.2126 | **57°** | 0.8387 | 0.5446 | 1.5399 |
| **13°** | 0.2250 | 0.9744 | 0.2309 | **58°** | 0.8480 | 0.5299 | 1.6003 |
| **14°** | 0.2419 | 0.9703 | 0.2493 | **59°** | 0.8572 | 0.5150 | 1.6643 |
| **15°** | 0.2588 | 0.9659 | 0.2679 | **60°** | 0.8660 | 0.5000 | 1.7321 |
| **16°** | 0.2756 | 0.9613 | 0.2867 | **61°** | 0.8746 | 0.4848 | 1.8040 |
| **17°** | 0.2924 | 0.9563 | 0.3057 | **62°** | 0.8829 | 0.4695 | 1.8807 |
| **18°** | 0.3090 | 0.9511 | 0.3249 | **63°** | 0.8910 | 0.4540 | 1.9626 |
| **19°** | 0.3256 | 0.9455 | 0.3443 | **64°** | 0.8988 | 0.4384 | 2.0503 |
| **20°** | 0.3420 | 0.9397 | 0.3640 | **65°** | 0.9063 | 0.4226 | 2.1445 |
| **21°** | 0.3584 | 0.9336 | 0.3839 | **66°** | 0.9135 | 0.4067 | 2.2460 |
| **22°** | 0.3746 | 0.9272 | 0.4040 | **67°** | 0.9205 | 0.3907 | 2.3559 |
| **23°** | 0.3907 | 0.9205 | 0.4245 | **68°** | 0.9272 | 0.3746 | 2.4751 |
| **24°** | 0.4067 | 0.9135 | 0.4452 | **69°** | 0.9336 | 0.3584 | 2.6051 |
| **25°** | 0.4226 | 0.9063 | 0.4663 | **70°** | 0.9397 | 0.3420 | 2.7475 |
| **26°** | 0.4384 | 0.8988 | 0.4877 | **71°** | 0.9455 | 0.3256 | 2.9042 |
| **27°** | 0.4540 | 0.8910 | 0.5095 | **72°** | 0.9511 | 0.3090 | 3.0777 |
| **28°** | 0.4695 | 0.8829 | 0.5317 | **73°** | 0.9563 | 0.2924 | 3.2709 |
| **29°** | 0.4848 | 0.8746 | 0.5543 | **74°** | 0.9613 | 0.2756 | 3.4874 |
| **30°** | 0.5000 | 0.8660 | 0.5774 | **75°** | 0.9659 | 0.2588 | 3.7321 |
| **31°** | 0.5150 | 0.8572 | 0.6009 | **76°** | 0.9703 | 0.2419 | 4.0108 |
| **32°** | 0.5299 | 0.8480 | 0.6249 | **77°** | 0.9744 | 0.2250 | 4.3315 |
| **33°** | 0.5446 | 0.8387 | 0.6494 | **78°** | 0.9781 | 0.2079 | 4.7046 |
| **34°** | 0.5592 | 0.8290 | 0.6745 | **79°** | 0.9816 | 0.1908 | 5.1446 |
| **35°** | 0.5736 | 0.8192 | 0.7002 | **80°** | 0.9848 | 0.1736 | 5.6713 |
| **36°** | 0.5878 | 0.8090 | 0.7265 | **81°** | 0.9877 | 0.1564 | 6.3138 |
| **37°** | 0.6018 | 0.7986 | 0.7536 | **82°** | 0.9903 | 0.1392 | 7.1154 |
| **38°** | 0.6157 | 0.7880 | 0.7813 | **83°** | 0.9925 | 0.1219 | 8.1443 |
| **39°** | 0.6293 | 0.7771 | 0.8098 | **84°** | 0.9945 | 0.1045 | 9.5144 |
| **40°** | 0.6428 | 0.7660 | 0.8391 | **85°** | 0.9962 | 0.0872 | 11.4301 |
| **41°** | 0.6561 | 0.7547 | 0.8693 | **86°** | 0.9976 | 0.0698 | 14.3007 |
| **42°** | 0.6691 | 0.7431 | 0.9004 | **87°** | 0.9986 | 0.0523 | 19.0811 |
| **43°** | 0.6820 | 0.7314 | 0.9325 | **88°** | 0.9994 | 0.0349 | 28.6363 |
| **44°** | 0.6947 | 0.7193 | 0.9657 | **89°** | 0.9998 | 0.0175 | 57.2900 |
| **45°** | 0.7071 | 0.7071 | 1.0000 | **90°** | 1.0000 | 0.0000 | ∞ |

**Appendix 2**

## Formulas and Quantities

### EQUATIONS

#### OPTICS

$n_1 \sin \theta_1 = n_2 \sin \theta_2$

$M = \dfrac{h_i}{h_o}$

$M = \dfrac{h_i}{h_o} = -\dfrac{d_i}{d_o}$

$\dfrac{1}{f} = \dfrac{1}{d_o} + \dfrac{1}{d_i}$

$n = \dfrac{c}{v}$

#### MECHANICS

$v_{av} = \dfrac{\Delta d}{\Delta t}$

$a = \dfrac{\Delta v}{\Delta t}$

$\Delta d = \left(\dfrac{v_1 + v_2}{2}\right)\Delta t$

$\Delta d = v_1 \Delta t + \dfrac{1}{2} a \Delta t^2$

$v_2 = v_1 + a\Delta t$

$v_2^2 = v_1^2 + 2a\Delta d$

$P = \dfrac{W}{\Delta t}$

$W = F\Delta d$

$E_g = mgh$

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

$F = ma$

$F_g = mg$

$F = kx$

$F_c = \dfrac{mv^2}{r}$

#### MATHEMATICS

$x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

### PHYSICAL CONSTANTS

| SYMBOL | QUANTITY | VALUE |
|---|---|---|
| $c$ | Speed of light in a vacuum | $3.00 \times 10^8$ m/s |
| $g$ | Acceleration due to gravity (earth) | 9.8 m/s$^2$ |