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Q1

1

A speedboat accelerates from rest to 90 mph in 5 seconds. The distance travelled, d meters, in time t seconds, can be modelled by a quadratic equation in the form $d = kt^2$. When $t = 2$ the speedboat has travelled a distance of 80.4 m.

(i) Use the model to find the distance travelled when the boat reaches 90 mph.
(ii) For what range of values is t valid for this model. Give a reason for your answer.

[5]

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i) SOLVE PROPORTIONALITY EQUATION TO FIND K

$80.4 = 2^2 k$

$k = \frac{80.4}{4} = 20.1$

$d = 20.1t^2$

TIME WHEN BOAT REACHES 90 MPH = 5 SECONDS

$d = 20.1 \times 5^2 = 502.5$

$d = 502.5m$

ii) $0 < t < 5$

AS ONLY VALID WHILE BOAT IS ACCELERATING, AFTER WHICH DISTANCE = SPEED x TIME

Q2a

2a

A stone is thrown from the edge of a lake into the water. The height of the stone above the water level h m, at time t seconds after it is thrown is modelled by a quadratic equation in the form $h = at^2 + bt + c$.

(a) Explain why the value of a must be negative and what the variable c must indicate.

[2]

(b) (i) Explain why the model may not be valid for $h < 0$.
(ii) Describe a situation where the model might only be valid for $h \geq 0$.

[3]

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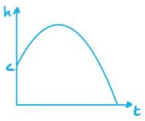
a)



HEIGHT WILL GO UP THEN DOWN OVER TIME SO QUADRATIC MUST BE NEGATIVE

ax^2 WITH $a < 0$ GIVES NEGATIVE CURVE

C MUST BE STARTING HEIGHT OF THROW AS AT $t = 0$ $h = c$

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Q2b

2b

A stone is thrown from the edge of a lake into the water. The height of the stone above the water level h m, at time t seconds after it is thrown is modelled by a quadratic equation in the form $h = at^2 + bt + c$.

(a) Explain why the value of a must be negative and what the variable c must indicate.

[2]

(b) (i) Explain why the model may not be valid for $h < 0$.
(ii) Describe a situation where the model might only be valid for $h \geq 0$.

[3]

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b)

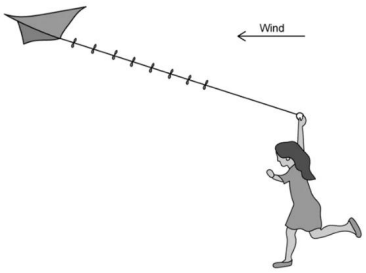
i) H<0 WOULD BE BELOW WATER LEVEL, AIR RESISTANCE AND WATER RESISTANCE ARE DIFFERENT SO MODEL MAY CHANGE

ii) IF THE LAKE WERE FROZEN THE STONE COULD LAND ON THE ICE

Q3

3

The diagram below shows a child holding onto a kite flying in the wind. Label the diagram with the appropriate forces, explain any assumptions you make about the diagram.



[3]

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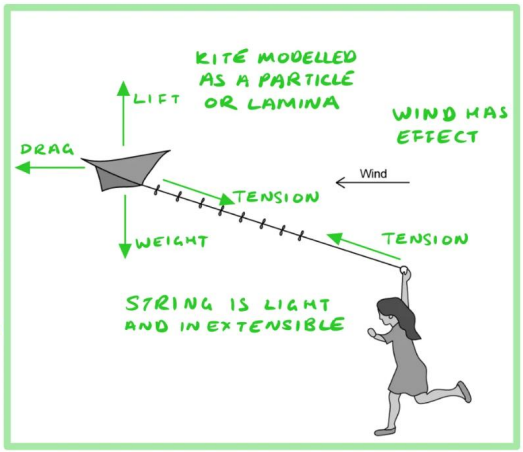

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Q4

4

Define each of the following and give an example of how they could be used in a mathematical model, include any related assumptions which can be made.

(i) A rough surface and a smooth pulley.
(ii) A peg and inextensible string.

[6]

i) ROUGH SURFACE WOULD CAUSE FRICTION FOR ANYTHING BEING PULLED ALONG IT, SMOOTH PULLEY WOULD ALLOW STRING TO PASS OVER WITHOUT FRICTION AND SAME TENSION EITHER SIDE

A BOX BEING PULLED UP A ROUGH RAMP BY A PULLEY

ii) A PEG IS A SUPPORT WHICH DOESN'T MOVE WHICH SOMETHING CAN BE HUNG ON, INEXTENSIBLE STRING MEANS DOES NOT STRETCH

A PICTURE HANGING ON A HOOK BY WIRE

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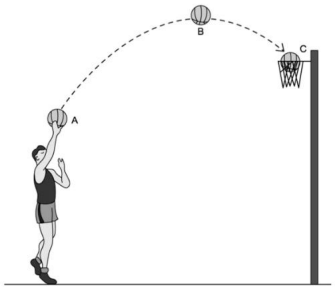
Q5a

5a

The diagram below shows a basketball player taking a shot.

(a) Label the forces on the ball at the three different stages of the throw.

A: As the player takes the shot, with their hands still in contact with the ball.
B: When the ball is in flight at its maximum height.
C: When the ball reaches the basket, hitting the back of the metal rim.

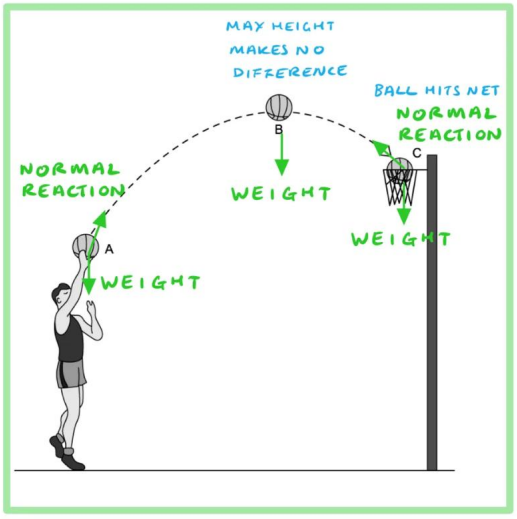


[6]

(b) List any assumptions you made for each, or all, stages of the throw *A*, *B* and *C* in order to answer part (a).

[3]

a)



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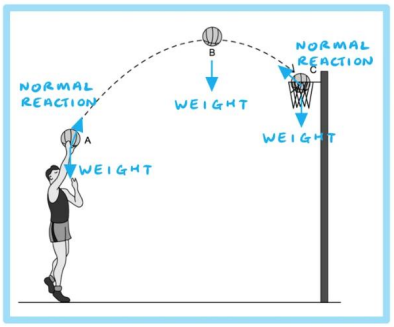
Q5b

5b

The diagram below shows a basketball player taking a shot.

(a) Label the forces on the ball at the three different stages of the throw.

A: As the player takes the shot, with their hands still in contact with the ball.
B: When the ball is in flight at its maximum height.
C: When the ball reaches the basket, hitting the back of the metal rim.



[6]

(b) List any assumptions you made for each, or all, stages of the throw *A*, *B* and *C* in order to answer part (a).

b)

BALL MODELLED AS PARTICLE THROUGHOUT

IGNORE AIR RESISTANCE AND ROTATIONAL EFFECTS ON THE BALL

BALL IS RIGID AND DOES NOT CHANGE SHAPE AT ANY STAGE e.g WHEN HITTING RIM OF BASKET

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Q6a

6a

Draw a simple diagram to represent each of the following models. Label your diagrams with the appropriate forces involved and detail any assumptions you make about each model.

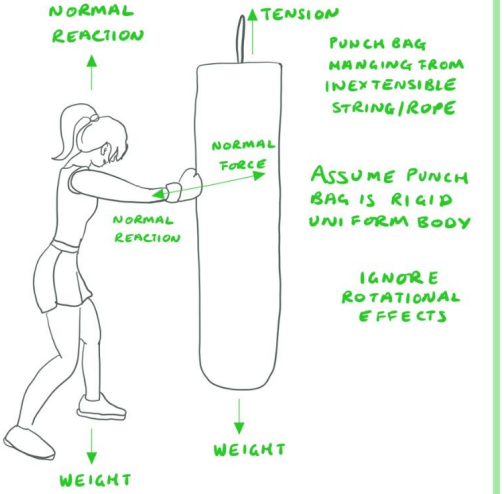
(a) A boxer hitting a punch bag suspended from the ceiling.

[4]

(b) The forces acting on a cat batting at a piece of string held by its owner.

[4]

a)



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Q6b

6b

Draw a simple diagram to represent each of the following models. Label your diagrams with the appropriate forces involved and detail any assumptions you make about each model.

(a) A boxer hitting a punch bag suspended from the ceiling.

[4]

(b) The forces acting on a cat batting at a piece of string held by its owner.

[4]

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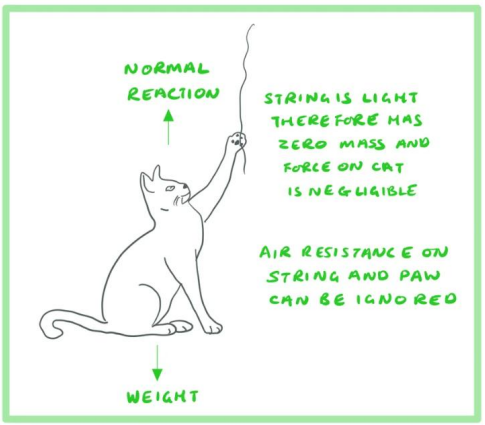
b)



Q7

7

A particle is attached to the end of a rod. One end of the rod is fixed to a wall using a hinge, the other end is held using a piece of string before it is let go.

State all the assumptions that would need to be made to model the situation above. You may draw a diagram to support your answer.

[3]

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