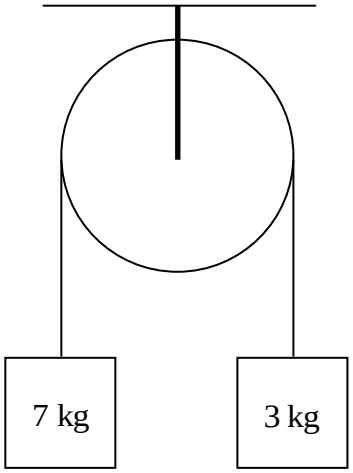
ROUND ONE

1. A car is travelling along a straight line with a uniform acceleration. It covers $120\ \text{m}$ in $20\ \text{s}$ and then $300\ \text{m}$ in the next $28\ \text{s}$. Calculate the initial speed of the car, to one decimal place.

2. The Atwood Machine was invented in 1784 by Rev. George Atwood [England] to verify the mechanical laws of motion. A simple version could be constructed as follows:

   A fixed smooth pulley has masses of $7\ \text{kg}$ and $3\ \text{kg}$ hanging freely from each side by means of a light inextensible string as shown in the diagram. The system is released from rest. Find the time taken for the $3\ \text{kg}$ mass to rise $1\ \text{m}$. Give your answer in seconds correct to one place of decimal.



3. Consider these statements:

   One: $a+b+c=x$

   Two: $a\times b\times c=x$

   Find the value of x if each of a,b and c is a positive integer less than 10.

ROUND TWO

1. Two runners are running in a race along a straight road which heads north. At a certain instant, athlete P is d metres from the finishing line and is running with a constant speed of $7\,\text{m/s}$. At this instant athlete Q is 8 metres behind P and is running with a constant speed of $9\,\text{m/s}$. Q just catches P on the finishing line, and the race ends in a dead heat. Find the value of d.

2. A smooth sphere P, of mass m, and moving with a speed $6\,\text{m/s}$ collides directly with another smooth sphere Q, of equal mass m, moving in the same direction with speed $2\,\text{m/s}$ on a smooth horizontal table. After the collision both spheres P and Q keep moving in the same direction, with speeds in the following ratio:

   $$\text{Speed of } P : \text{Speed of } Q = 3:5$$

   Find the coefficient of restitution for the collision.

3. According to a headline, 'Glaciers in the French Alps have lost a quarter of their area in the past 40 years'. What is the approximate percentage reduction in the length of a side of a square when it loses on quarter of its area, thereby becoming a smaller square?

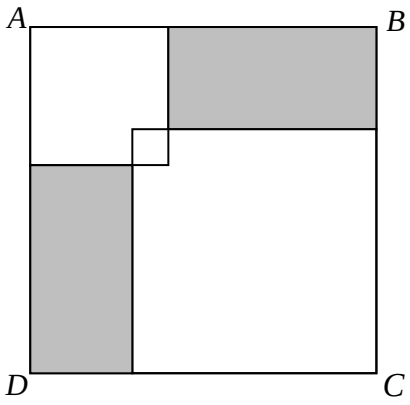
   A: 13% B: 25% C: 38% D: 50% C: 65%

ROUND THREE

1. A ball thrown with a speed of $35\,\text{m/s}$ at an angle α to the horizontal reaches a maximum height of 40 m. Find the horizontal range of the particle. Give your answer correct to the nearest metre. $\left[g = 10\,\text{m/s}^2 \right]$

2. A train accelerates uniformly from rest to a speed $v\,\text{m/s}$ with uniform acceleration $a\,\text{m/s}^2$. It then decelerates uniformly to rest with uniform retardation $3a\,\text{m/s}^2$. The total distance travelled is s metres. If the average speed for the whole journey is $\sqrt{\frac{s}{2}}\,\text{m/s}$, find the value of a. Give your answer as a fraction.

3. The square $ABCD$ has an area of 196. It contains two overlapping squares; the larger of these squares has an area 4 times that of the smaller and the area of their overlap is 1. What is the total area of the shaded regions?



A: 44 B: 72 C: 80 D: 152

E: more information is needed

ROUND FOUR

1. Two cars A and B are moving along straight roads which are at right angles to each other, with uniform velocities 3m/s and 6m/s, respectively. When A is at the crossroads, B is 80m away. Calculate the time interval for which the distance between the cars is not greater than 70 m. Give your answer correct to the nearest second.

2. A particle is projected up an inclined plane with initial speed u. The line of projection makes an angle α with the plane and the plane is inclined at $60°$ to the horizontal. The plane of projection is vertical and contains the line of greatest slope. If the direction of motion of the particle makes an angle of $\tan^{-1}3$ with the plane when it lands, find the value of α. Give your answer in degrees correct to one place of decimals. $\left[g = 10\text{m/s}^2 \right]$

3. There are four clocks in a room A, B, C and D.

   A gains a minute every hour.

   B loses a minute every hour.

   C runs backwards at the normal speed.

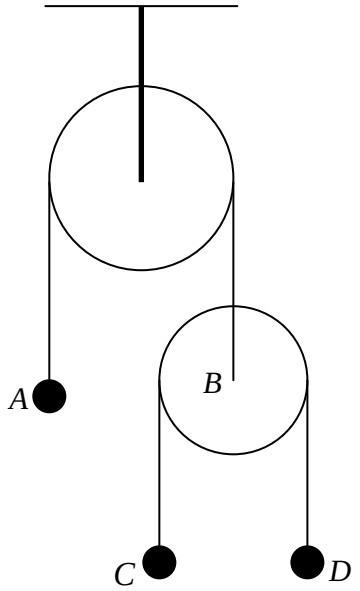
   D always keeps the correct time.

   At $07:03$ today they all show the same time which was correct.

   After how many days will they all again show the correct time?

ROUND FIVE

1. A particle A of mass $6\,\text{kg}$ is connected by a light inextensible string passing over a fixed smooth pulley to a light smooth moveable pulley B. Two particles C and D of masses $2\,\text{kg}$ and $1\,\text{kg}$ are connected by a light inextensible string passing over the pulley B. When the system is moving freely, find the downwards acceleration of A.



$\left[g = 10\,\text{m/s}^2 \right]$

Give your answer correct to two places of decimals

2. A smooth sphere of mass $1\,\text{kg}$ moving with velocity $3\vec{i} + \vec{j}$ collides with a smooth sphere of mass M moving with velocity $\vec{i} + 2\vec{j}$ on a smooth horizontal table.

After the collision the spheres move in parallel directions.

The coefficient of restitution between the spheres is $\frac{1}{2}$.

Find the value of M.

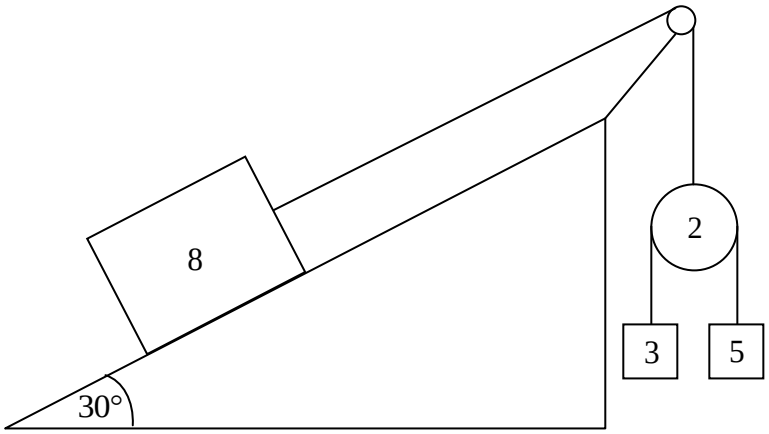
3. In a 'ninety nine' shop, all items cost a number of euros and 99 cents. Susanna spent €65.76. How many items did she buy?

A: 23 B: 24 C: 25 D: 60 E: 76

ROUND SIX

1. A speedboat is travelling due East at $100\,\text{km/hour}$ and at an instant is $500\,\text{m}$ due North of a launch which is trying to catch the speedboat. If the maximum speed of the launch is $60\,\text{km/hour}$ calculate, to the nearest metre, how close it can get to the speedboat.

2. A particle of mass $8\,\text{kg}$ lies on a rough plane which is inclined at $30°$ to the horizontal.



The coefficient of friction between the particle and the plane is $\frac{1}{\sqrt{3}}$. The $8\,\text{kg}$ mass is connected by a light inextensible string passing over a smooth light pulley at the top of the plane to a pulley of mass $2\,\text{kg}$ hanging freely. Over this pulley (which is also smooth) a second light inextensible string is passed having particles of mass $3\,\text{kg}$ and $5\,\text{kg}$ attached. Find the acceleration of the $8\,\text{kg}$ mass. Give your answer as a fraction. $\left[g = 10\,\text{m/s}^2 \right]$

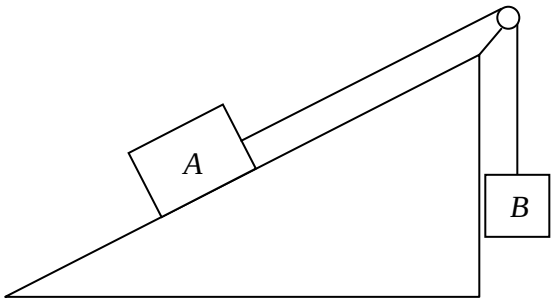
3. A team wins 60% of its games in the first third of a season. What percentage of the remaining games must it win to finish the season having won 80% of the games?

TIE-BREAKERS

1. Particle A of mass $4\,\text{kg}$ rests on a fixed smooth plane inclined at an angle θ where $\theta = \sin^{-1}\left(\frac{3}{20}\right)$.

   Particle B of mass $6\,\text{kg}$ is hanging freely. A and B are connected by a light inextensible string passing over a smooth pulley P.

   Find the acceleration of the system.



2. A smooth sphere A of mass $5\,\text{kg}$ which is travelling with speed u collides directly with a stationery sphere B of mass $2\,\text{kg}$. The coefficient of restitution between the spheres is e.

   Find, in terms of u, the maximum possible velocity of sphere A after the collision.

ANSWERS

	Question 1	Question 2	Question 3
Round 1	$5 \cdot 8 \text{m/s}$	$0 \cdot 7$ seconds	6
Round 2	28 m	$\frac{1}{2}$	*A*
Round 3	117 m	$\frac{4}{3}$	*B*
Round 4	18 seconds	$14 \cdot 8°$	60 days
Round 5	$3 \cdot 85 \text{m/s}^2$	2 kg	*B*
Round 6	400 m	$\frac{6}{7}$	90%
Tie-Breakers	$5 \cdot 4 \text{m/s}^2$	$\frac{5u}{7}$	