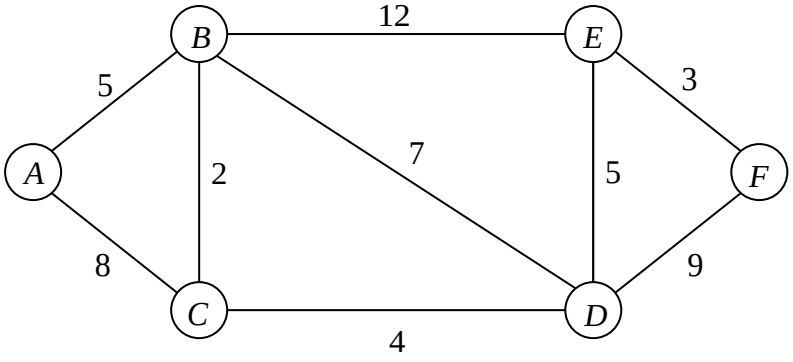
Round One

1. A racing car is travelling at $60\,\text{m/s}$ when the driver sees a broken-down car on the track $\frac{1}{5}$ of a kilometre ahead.

   Slamming on his brakes he achieves his maximum deceleration of $12\,\text{m/s}^2$.

   How far short of the broken-down car does he stop?

2. A competitor is attempting a dive from a springboard which is 6 m above the water. She leaves the board with an upward velocity of $7\,\text{m/s}$. Find the time for which the competitor is in the air before entering the water. $\left[g = 10\,\text{m/s}^2 \right]$.

3. 

   Find the shortest path from A to F in the above network, by letter indication.

   (Diagram is not to scale)

Round Two

1. The velocities of a helicopter and light aircraft are $\left(15\vec{i}+8\vec{j}\right)\text{m/s}$ and $\left(-3\vec{i}+9\vec{j}\right)\text{m/s}$ respectively.

   What is the speed of the helicopter relative to the light aircraft? Give answer correct to two places of decimals.

2. An aircraft P is 1200 m due North of another aircraft Q. When observed, both are flying at the same height with constant velocities. P is flying at $150\,\text{m/s}$ due West and Q is flying at $200\,\text{m/s}$ in the direction North $30°$ West.

   Find the distance between the two aircraft when they are closest together. Give answer to nearest metre.

3. Alex Erlich and Paneth Farcas shared an opening rally of two hours and twelve minutes during their table tennis match at the 1936 World Games. Each player hit around 45 shots per minute. Which of the following is closest to the total number of shots played in the rally?

   A: 200 B: 2,000 C: 8,000 D: 12,000 E: 20,000

Round Three

1. A particle is projected on a horizontal plane with a velocity vector $a\vec{i}+b\vec{j}$. After 5 seconds the velocity vector is $40\vec{i}+60\vec{j}$. Write the ratio $a:b$ as a simple fraction.

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

2. A particle P is projected from a point k with velocity $12\vec{i}+16\vec{j}$. Two seconds later another particle Q is projected from k and collides with P after another second. If the event occurs on a horizontal plane, find the initial velocity of Q in terms of $\vec{i}$ and $\vec{j}$.

3. Each of the Four Musketeers made a statement about the four of them, as follows.

   d'Artagnan: “Exactly one of us is lying.”

   Athos: “Exactly two of us are lying.”

   Porthos: “An odd number of us is lying.”

   Aramis: “An even number of us is lying.”

   How many of them were lying (with the others telling the truth)?

   A: one B: one or two C: two or three D: three E: four

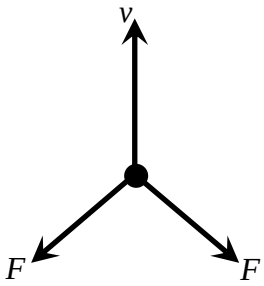
Round Four

1. Each of the figures below shows a particle moving with velocity v, and with one or two forces of magnitude F acting upon it. In which of the figures will v remain constant?

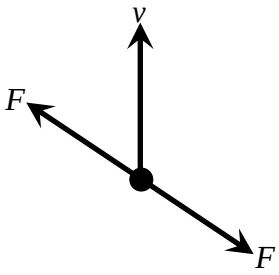
(A)

(B)

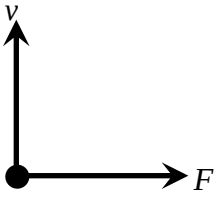
(C)



(D)



(E)



2. A light inextensible string passes over a smooth fixed pulley and carries particles of masses 4 kg and 16 kg, one at each end. If the system is moving freely, find the force exerted on the pulley by the string.

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

3. A car with five tyres [four road tyres and a spare] travelled 30,000 km. All five tyres were used equally. How many thousand kilometres wear did each receive?

A: 6 B: 30 C: 24 D: 7.5 E: None of these answers

Round Five

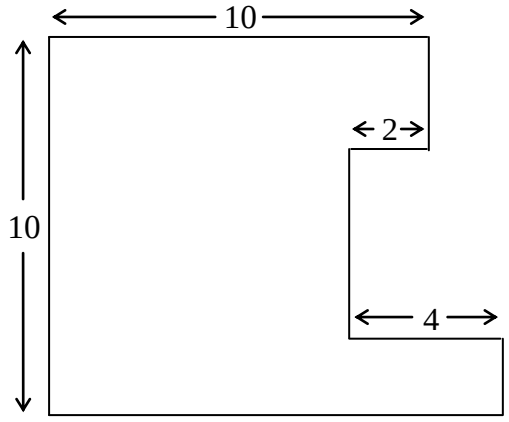
1.

The left hand diagram shows two balls, A and B, on a horizontal plane approaching each other so as to collide directly. The speeds of balls A and B immediately before collision are $6\ \text{m s}^{-1}$ and $3\ \text{m s}^{-1}$, respectively. Ball A is of mass $0{\cdot}4\ \text{kg}$ whilst the mass of ball B is $0{\cdot}2\ \text{kg}$. The coefficient of restitution for collision between the balls is $\frac{1}{3}$. The right hand diagram shows the motion of the balls immediately after collision when their velocities to the right are denoted by $v_A\ \text{m s}^{-1}$ and $v_B\ \text{m s}^{-1}$ respectively. Modelling the balls as particles, find the total change in kinetic energy due to the collision.

2. A boy's ball lands on a pond covered with thin ice. He attempts to push it to the other side by throwing stones at it. The mass of the ball is $0{\cdot}4\ \text{kg}$ and the stones he selects all have a mass $0{\cdot}1\ \text{kg}$. The coefficient of restitution between the stones and the ball is $\frac{1}{2}$ and he throws the stones so that they hit the ball with a horizontal speed of $10\ \text{m s}^{-1}$.

Find the speed of the ball after it has been struck by the second stone.

[You may assume that there is zero friction between the ball and the ice].

3. 

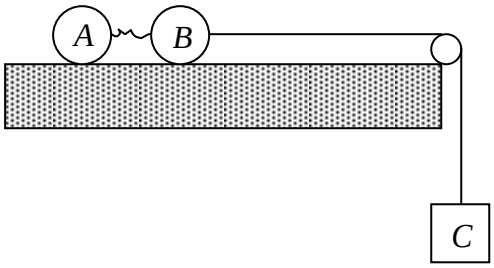
Find the perimeter of this figure if all lines are vertical or horizontal.

Round Six

1. A and B are two particles of mass 4 kg and 8 kg, respectively, lying in contact on a smooth table and connected by a string of length 3 m. B is 7 m from the smooth edge of the table and is connected by a taut string passing over the edge of the table to a particle C of mass 4 kg hanging freely. Find the speed of A directly after the string connecting A and B becomes taut, B having moved 3 metres.

   [Answer to one place of decimals, $g = 10\,\mathrm{m/s^2}$].

   The string connecting A and B is initially slack.



2. A particle is initially at a point A on a smooth horizontal surface midway between two vertical walls which are parallel to each other and 2 metres apart. The particle is projected from A with a speed of $2\,\mathrm{m/s}$ in a direction perpendicular to the walls.

   If the coefficient of restitution between the particle and each wall is $\frac{1}{2}$, find the time taken for the body to return to A having touched each wall once and once only.

3. Jack and Jill went up the hill to fetch a pail of water. Having filled the pail (bucket) to the top, Jack fell down, spilling $\frac{2}{3}$ of the water, before Jill caught the pail. She then tumbled down, spilling $\frac{2}{5}$ of the remainder. What fraction of the pail does the remaining water fill?

   A: $\frac{11}{15}$ B: $\frac{1}{3}$ C: $\frac{4}{15}$ D: $\frac{1}{5}$ E: $\frac{1}{15}$

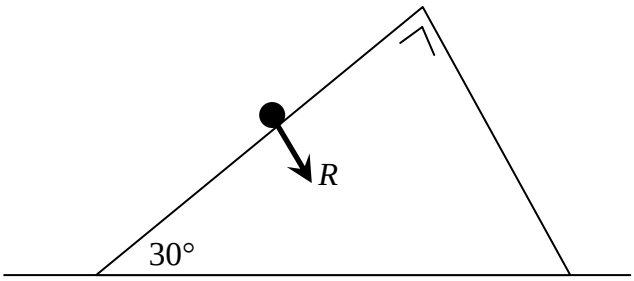
Round Seven

1. A particle is projected up an inclined plane with a speed of $50\,\text{m/s}$. The line of projection makes an angle θ with the horizontal and the plane is inclined at $40°$ to the horizontal. The particle lands after 7 seconds. Find the value of θ to the nearest degree.

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

2. The diagram shows the forces that are acting on a wedge which is in contact with a rough horizontal table. If the mass of the wedge is 10 kg, $R = 6g$ and the coefficient of friction between the wedge and the table is $\frac{1}{7}$, find the acceleration of the wedge.

   [Answer to one place of decimals, $g = 10\,\text{m/s}^2$].



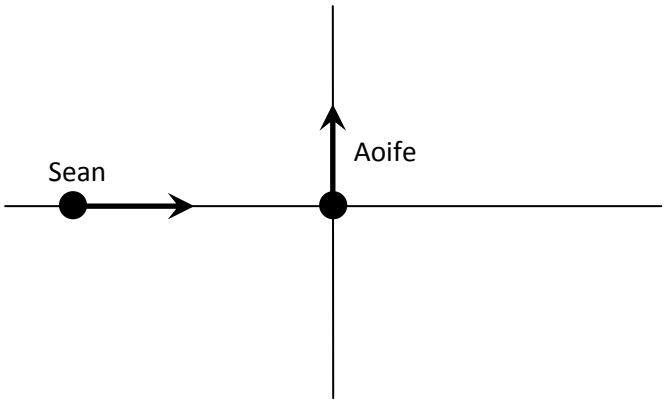
3. At half-time, St. John's had scored all of the points so far in their annual match against a rival school. In the second half, each side scored three points. At the end of the match, St. John's had scored 90% of the points.

   What percentage of the points in the match was scored in the second half?

Round Eight

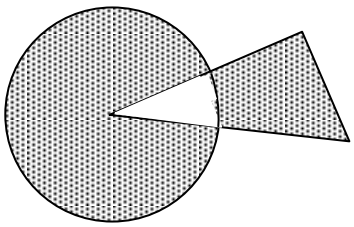
1. Two straight roads intersect at right angles at a junction k. Sean, who is 30 metres from k, starts from rest and accelerates at 1m/s^2 in an easterly direction. Aoife, who is at k, has an initial velocity of 3m/s and accelerates at 2m/s^2 in a northerly direction. At a certain instant the relative speed of the two cyclists is 7m/s. How far beyond the junction has Aoife progressed at that instant?

   [Answer to nearest metre].



2. A smooth sphere of mass M collides obliquely with a second smooth sphere at rest. The direction of motion of the moving sphere is inclined at $45°$ to the line of centres at impact and the coefficient of restitution is $\frac{1}{2}$. After impact the directions of motion of the spheres are at right angles. Find the mass of the second sphere in terms of M.

3. In the diagram $\frac{5}{6}$ of the circle is shaded and $\frac{2}{3}$ of the triangle is shaded. What is the ratio of the area of the circle to the area of the triangle?



Tie Breaker 1

How many minutes will elapse between 20:12 today and 21:02 tomorrow?

Tie Breaker 2

A smooth sphere A of mass $4m$ travelling with speed u collides directly with a smooth sphere B of mass m. The coefficient of friction between the spheres is e.

Find the maximum velocity of sphere A after the collision.

Tie Breaker 3

A car of mass 900 kg increases its speed from 10 m/s to 30 m/s. Find the increase in kinetic energy.

Rules for Tie Breakers

1. A maximum of 6 minutes to be allowed per tie break round.
2. Teams may submit their answer before the final signal.
3. If two or more teams are still tied on their scores after this round, then the tying team which submitted its answer paper first will be deemed to have won, and so on. (Note: The score is the primary criterion).
4. Should a tie still remain after all tie-break questions have been used, then the adjudicator, at his or her discretion, will decide how the matter is to be resolved.

Answers

Round 1:	1.	50 m	2.	2 seconds	3.	ABCDEF
Round 2:	1.	$18 \cdot 03 \text{m/s}$	2.	331, 332, 333, 334 (All acceptable)	3.	D
Round 3:	1.	$\frac{4}{11}$	2.	$36\vec{i} + 8\vec{j}$	3.	C
Round 4:	1.	D	2.	128 N	3.	C
Round 5:	1.	$4 \cdot 8 \text{ J}$	2.	$5 \cdot 1 \text{m/s}$	3.	48
Round 6:	1.	$3 \cdot 3 \rightarrow 3 \cdot 4 \text{m/s}$ (Range of answers)	2.	$4 \cdot 5 \text{ s}$	3.	D
Round 7:	1.	$72°$	2.	$0 \cdot 8 \text{m/s}^2$	3.	20%
Round 8:	1.	9 m	2.	$2M$	3.	$2:1$

Tie-Break 1: 1490 minutes

Tie-Break 2: $\frac{4u}{5}$

Tie-Break 3: 360 kJ or $360,000 \text{ J}$