# AQA A-Level Maths: Practice Paper 3

**Focus:** Mechanics

**Difficulty:** Hard

**Time**: 2 hours

**Marks:**

Section A (multiple choice): 10 marks (15 minutes)

Section B (standard questions): 80 marks (1 hour 45 minutes)

(Total 90 marks)

**Grade Boundaries:** (approximate)

A*: 72 (80%)

A: 63 (70%)

B: 54 (60%)

C: 45 (50%)

D: 36 (40%)

**Main Topics Examined:**

Variable Acceleration, Velocity-Time Graphs, Projectile Motion, Dynamics, Newton's 2nd Law, Moments and Static Equilibrium

**Advice:**

1. Read the questions carefully - look out for tricks.
2. Some questions are harder than the A-level standard.
3. Apply existing knowledge to unfamiliar questions.
4. Check the fully worked solutions for any questions you missed.

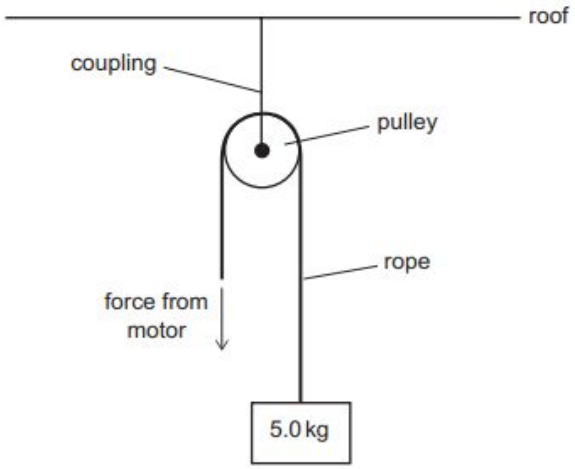
**Section A: Multiple choice**. You are advised to spend no more than **15 minutes** in Section A.

1. The point *A* is 4 km due East of the point *B*. The bearing of the point *C* from *A* is 330° and the bearing of *C* from *B* is 060°.

   The distance *BC* is

   O 2 km
   O $2\sqrt{3}$ km
   O 4 km
   O $2\sqrt{5}$ km [1 mark]

2. A motor is used to lift a mass of 5.0 kg using a pulley system as shown in the diagram. The pulley is secured to the roof using a coupling.



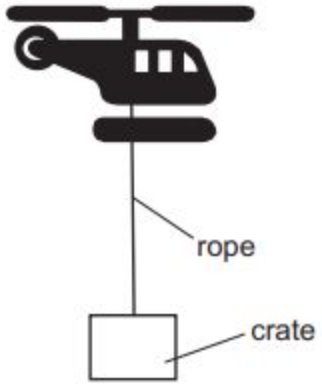

   The motor needs to cause the mass to accelerate upwards at 0.80 $ms^{-2}$.

   What is the minimum tension force that the coupling must be able to withstand without breaking?

   (The gravitational field strength *g* is 10 N $kg^{-1}$. The pulley system is frictionless and has negligible mass. The rope has negligible mass and is inextensible.)

   O 46 N
   O 54 N
   O 92 N
   O 108 N [1 mark]

3. A crate has a total mass of 800 kg, including its contents. A helicopter of mass 4200 kg is carrying the crate using a light inextensible rope as shown:

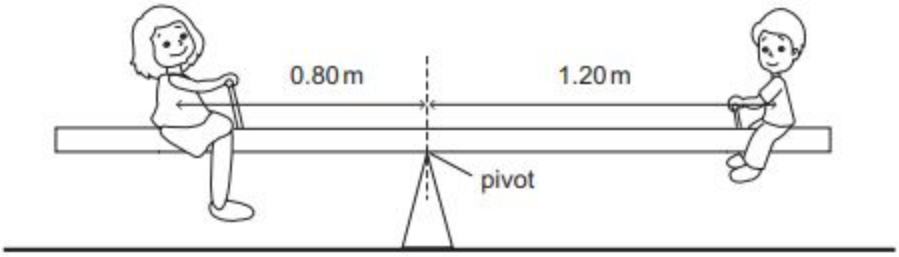



The helicopter and crate are accelerating upwards at 2.0 $ms^{-2}$. What is the tension in the rope?

(The gravitational field strength g is 10 N $kg^{-1}$; air resistance can be ignored.)

O 6.4 kN
O 8 kN
O 9.6 kN
O 18 kN [1 mark]

4. A plank of non-uniform density which has a mass of 15 kg is used to make a see-saw. A pivot is placed under the centre of the plank as shown on the diagram.




A boy of mass 35 kg sits at one end of the plank with his centre of gravity 1.20 m from the pivot. The see-saw balances when a woman of mass 60 kg sits on the plank on the other side of the pivot. Her centre of gravity is 0.80 m from the pivot.

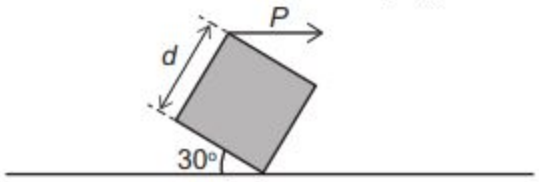
Where is the centre of gravity of the plank and what is the magnitude of the force between the pivot and the plank? (The gravitational field strength g is 10 N $kg^{-1}$.)

| | *distance from pivot* | *force* / N |
|---|---|---|
| O | 0.40 m on left of pivot | 1100 |
| O | at the pivot | 100 |
| O | 0.20 m on right of pivot | 100 |
| O | 0.40 m on right of pivot | 1100 |

[1 mark]

5. The diagram shows a uniform, solid, heavy cube with side *d*. The cube rests with one of its edges in contact with a table that is perfectly level. A horizontal force *P* acts on another edge of the cube, and the cube is stationary.

[diagram not to scale]




Which of these statements is true?

O It is possible that there is no frictional force between the cube and the table.

O There must be a frictional force acting to the left between the cube and the table.

O There must be a frictional force acting to the right between the cube and the table.

O Force *P* has a clockwise moment about the edge in contact with the table equal to $P \times d$. [1 mark]

6. An object is fired vertically upwards from the ground at time $t = 0$ s in still air at a speed of 8.0 $ms^{-1}$. On the way up, what is the height of the object above the ground when it has a speed of 2.0 $ms^{-1}$, and at what time does it reach this height on the way down?

(The gravitational field strength *g* is 10 N $kg^{-1}$. Air resistance can be ignored.)

| | *height* / m | *time* / s |
|---|---|---|
| O | 2.4 | 2.0 |
| O | 3.0 | 0.60 |
| O | 3.0 | 0.64 |
| O | 3.0 | 1.0 |

[1 mark]

7. A point object of mass 2.0 kg is at rest on a level, horizontal surface. The coefficient of friction between the object and the surface is 0.25. Two horizontal forces at right-angles to each other, with magnitudes 9.0 N and 12.0 N, are applied simultaneously to the object.

What is the magnitude of the acceleration of the object as it begins to move?

(The gravitational field strength $g$ is 10 N $kg^{-1}$.)

O 5 $ms^{-2}$
O 7.25 $ms^{-2}$
O 7.5 $ms^{-2}$
O 8 $ms^{-2}$ [1 mark]

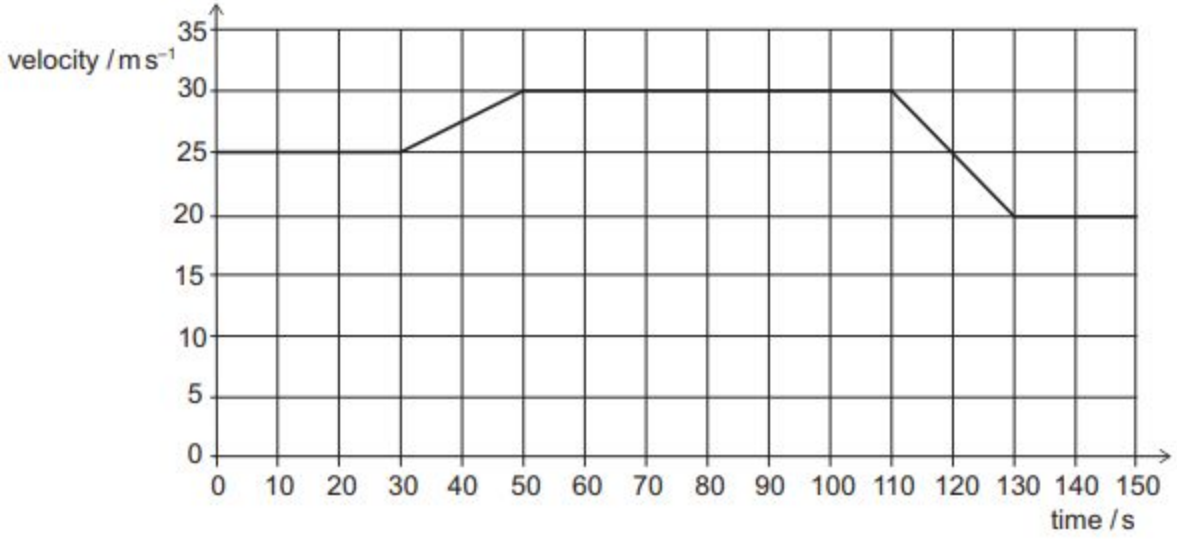
8. An object of mass 20 kg is pulled up a rough plane inclined at 30° to the horizontal by a light, inextensible cable attached via a frictionless pulley to a freely-falling 30 kg mass.

(Air resistance and the mass of the pulley can be ignored.)

If the acceleration of the object along the plane is 2.5 $ms^{-2}$ and $g$ = 10 $ms^{-2}$, then the frictional force between the object and the plane is

O 25 N
O 50 N
O 75 N
O 100 N [1 mark]

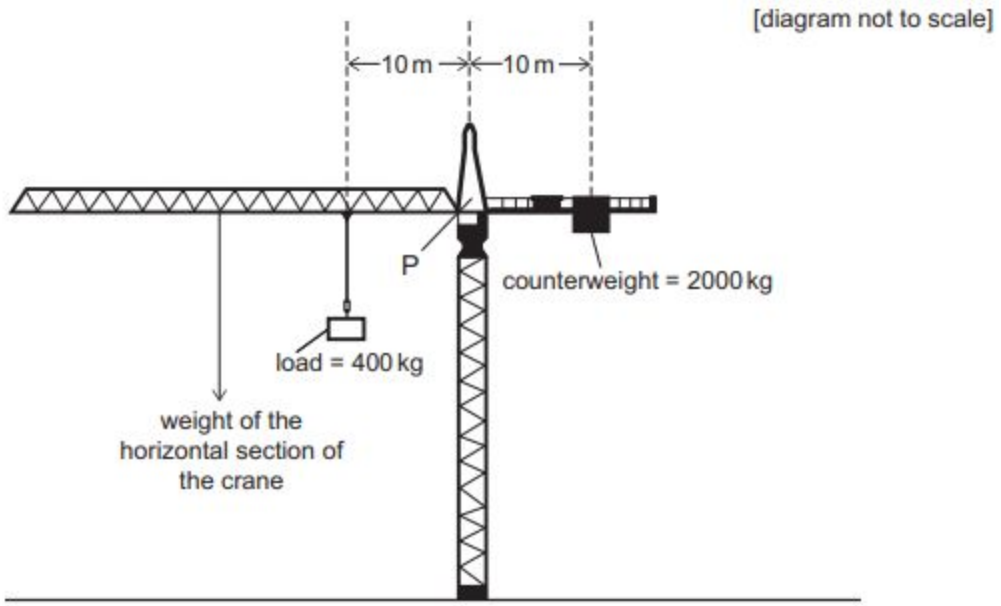
9. A car is travelling along a horizontal road in a straight line. The graph is a velocity–time graph for part of the car's journey.




During this part of the journey, what is the total distance that the car travels while it is decelerating?

O 500 m
O 600 m
O 650 m
O 750 m [1 mark]

10. The diagram shows a crane being used on a building site. The crane is perfectly balanced about *P*.




The load is now moved to the left by 5.0 m. To keep the crane perfectly balanced about *P*, how far does the counterweight have to move, and in which direction?

(gravitational field strength = 10 N $kg^{-1}$)

O 1.0 m to the left
O 1.0 m to the right
O 3.0 m to the left
O 3.0 m to the right [1 mark]

**Section B: Standard questions**.

11. The displacement of a particle *P* at time *t* moving in a straight line is given by

$$x = -\frac{1}{3}t^3 + 3t^2 + k$$

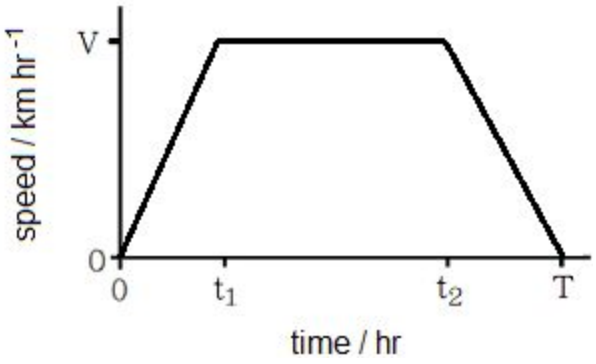
where *k* is a constant.

When the acceleration of *P* is 0, its position is 40 units from its starting point.

Find the value of k. [4 marks]

[Total for Q11: 4 marks]

12. The speed-time graph of a hovercraft is shown below.




The hovercraft accelerates uniformly at $m$ km hr$^{-2}$ for an initial period $t_1$, then travels at a constant speed $V$ km hr$^{-1}$, and finally decelerates uniformly at $m$ km hr$^{-2}$.

The distance covered in that time is $D$ km and the total time taken is $T$ hours.

a. If the time taken by acceleration and deceleration is $T/6$ in each case, find an equation for $D$ in terms of $T$ and $m$. [5 marks]

b. The hovercraft is running behind schedule and needs to reduce $T$ to $(7/9)T$. The only way of achieving this is to increase the value of $V$ while the acceleration and deceleration may not be changed from $m$.

What time, as a fraction of $T$, should now be spent accelerating? [9 marks]

c. By what percentage must the hovercraft's top speed increase? [3 marks]

[Total for Q12: 17 marks]

13. A grenade explodes on the surface of horizontal ground. Several fragments and dirt particles are scattered in all directions with varying velocities.

a. Show that the projectile particles with initial speed $v$ ms$^{-1}$ landing a distance $r$ m from the centre of explosion will do so at times $t$ s related by the equation

$$\frac{1}{2}g^2t^2 = v^2 \pm \sqrt{v^4 - g^2r^2}.$$

You may assume no air resistance and may also ignore the motion of particles directly into the ground. [10 marks]

b. Hence find an expression in terms of $v$, $r$ and $g$ for the greatest height $h$ reached by such projectile particles. [8 marks]

[Total for Q13: 18 marks]

14. A particle $P$ of mass 2 kg rests on a rough plane inclined at $45^{\circ}$ to the horizontal. The coefficient of friction between $P$ and the plane is 0.5. A light inextensible string attached to $P$ lies along the line of greatest slope of the plane and passes over a smooth fixed pulley at the top of the plane. Particle $Q$ of mass 5 kg hangs vertically from the other end of the string.

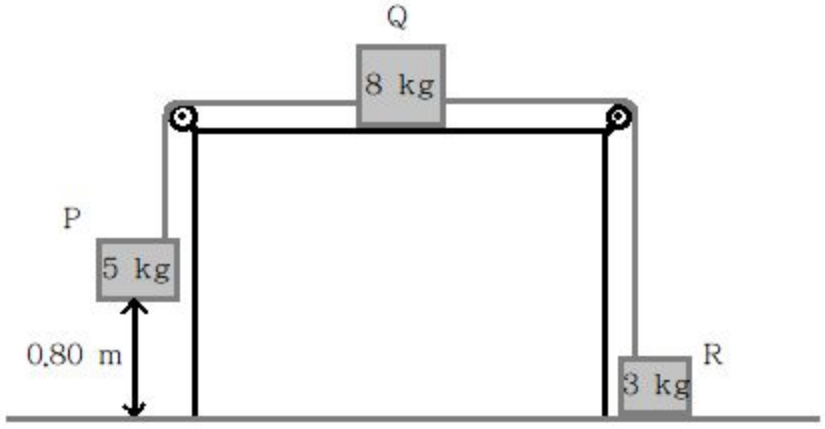
Particle $P$ is initially 3 m from the pulley while particle $Q$ is initially 2 m above the ground. The system is released from rest with the string taut.

a. Find the tension in the string. [4 marks]

b. Given that $Q$ hits the ground, determine whether particle $P$ will reach the pulley. Fully justify your answer. [6 marks]

[Total for Q14: 10 marks]

15. Three different blocks *P*, *Q* and *R* have masses 5.0 kg, 8.0 kg and 3.0 kg respectively. They are connected by two light inextensible strings over two smooth pulleys on a rough table in the setup shown below. Block *R* is initially held in contact with the floor.




When the system is released from rest, block *P* hits the ground in 1.32 seconds.

a. Calculate the coefficient of friction between block *Q* and the table. [9 marks]

b. Calculate the maximum height above the ground achieved by block *R* in centimeters after *P* hits the floor. [4 marks]

c. i) State one assumption you have made about blocks *P* and *R* in order for your calculations to be valid. [1 mark]

ii) State one assumption you have made about block *Q* in order for your calculations to be valid. [1 mark]

[Total for Q15: 15 marks]

16. A painter of weight $kW$ uses a ladder to reach the guttering on the outside wall of a house. The wall is vertical and the ground is horizontal. The ladder is modelled as a uniform rod of weight $W$ and length $6a$.

The ladder is not long enough, so the painter stands the ladder on a uniform table. The table consists of a square top of side $(1/2)a$ with a leg of length $a$ at each corner. The weight of the table is $2W$. The foot of the ladder is at the centre of the table top and the ladder is inclined at an angle $\tan^{-1}(2)^{o}$ to the horizontal.

The edge of the table nearest the wall is parallel to the wall. The coefficient of friction between the foot of the ladder and the table top is 1/2. The contact between the ladder and the wall is sufficiently smooth for the effects of friction to be ignored.

a. Show that, if the legs of the table are fixed to the ground, the ladder does **not** slip on the table however high the painter stands on the ladder. [8 marks]

b. It is given that $k = 9$ and that the coefficient of friction between each table leg and the ground is 1/3. The legs of the table are no longer fixed to the ground so that the table may tilt or slip, and the painter slowly climbs the ladder.

Determine whether the table **first** tilts **or** slips as the painter climbs.

[8 marks]

[Total for Q16: 16 marks]

**End of Questions**

## Question Sources

Q1-10: ENGAA/NSAA Past Paper (Physics)

Q11: CSAT Past Paper (Math A)
Q13: STEP I Past Paper
Q14: AQA A-Level Maths Past Paper
Q16: STEP II Past Paper

ENGAA is an entrance exam for studying Engineering at Cambridge.
NSAA is an entrance exam for studying Natural Sciences at Cambridge.
STEP I and II are entrance exams for studying STEM at Oxbridge and Durham.
CSAT is an exam in South Korea.