TRANSPORT

AVERAGE AND INSTANTANEOUS SPEED

1. A car travels 500 m in 30 s. Calculate its average speed.

2. A man walks 1 km in 10 min. Calculate his average speed.

3. A car is travelling at 90 km h^{-1} when the driver looks at the speedometer. However, it takes 3 h to travel 200 km.
   a) What is the average speed in kilometres per hour?
   b) Why is the instantaneous speed different from the average speed?
   c) What is the instantaneous speed in metres per second?

4. A train is travelling from Aberdeen to Inverness. Part of the train timetable is shown below.

Aberdeen	dep.	0628	
Inverurie	arr.	0650	19 km
	dep.	0705	
Elgin	arr.	0804	65 km
	dep.	0819	
Inverness	arr.	0857	81 km

   a) Calculate the average speed in kilometres per hour from Aberdeen to Inverurie.
   b) Calculate the average speed in kilometres per hour from Inverurie to Elgin.
   c) Calculate the average speed in kilometres per hour from Elgin to Inverness.
   d) Calculate the average speed in kilometres per hour from Aberdeen to Inverness.
   e) Calculate the average speed in metres per second from Aberdeen to Inverness.

5. A train is travelling from Glasgow to Edinburgh. Part of the train timetable is shown below.

Glasgow	dep.	1800	
Falkirk	arr.	1820	28 km
	dep.	1830	
Linlithgow	arr.	1838	12 km
	dep.	1840	
Edinburgh	arr.	1905	34 km

   a) Calculate the average speed in kilometres per hour from Glasgow to Falkirk.
   b) Calculate the average speed in kilometres per hour from Falkirk to Linlithgow.
   c) Calculate the average speed in kilometres per hour from Linlithgow to Edinburgh.
   d) Calculate the average speed in kilometres per hour from Glasgow to Edinburgh.
   e) Calculate the average speed in metres per second from Glasgow to Edinburgh.

6. a) A train is travelling from Dingwall to Kyle of Lochalsh. Part of the train timetable is shown below:

Dingwall	dep.	1111	
Achnasheen	arr.	1200	42 km
	dep.	1205	
Stromeferry	arr.	1250	42 km
	dep.	1252	
Kyle of Lochalsh	arr.	1315	18 km

i) Calculate the average speed in kilometres per hour from Dingwall to Achnasheen.
ii) Calculate the average speed in kilometres per hour from Achnasheen to Stromeferry.
iii) Calculate the average speed in kilometres per hour from Stromeferry to Kyle of Lochalsh.

b) A second train goes from Dingwall to Kyle of Lochalsh in 1 h 30 min.
i) Suggest a reason why it might be faster.
ii) Calculate the average speed in metres per second of the second train from Dingwall to Kyle of Lochalsh.

7. A plane leaves London at 7.25 G.M.T. and arrives in New York at 12.10 G.M.T.
a) How long did the plane take for the journey?
b) If it is 5100 km from London to New York, calculate the average speed
i) in kilometres per hour,
ii) in metres per second.
c) The return journey takes 4 h 15 min.
What is the average speed in kilometres per hour for this journey?
d) Suggest why the two average speeds might be different.

8. A ship takes 5 days and 19 h to travel from San Francisco to Honolulu. If the distance is 3885 km, calculate the average speed:
a) in kilometres per hour,
b) in metres per second.

9. A ship travels at an average speed of 28 km h^{-1} and takes 3 days and 19 h to travel from Glasgow to Gibraltar. How far does it travel?

10. A ship travels at an average speed of 42 km h^{-1} and takes 8 days and 5 h to travel from New Orleans to London. How far does it travel?

ACCELERATION $a = \frac{v - u}{t}$

11. Complete the following table:

	INITIAL VELOCITY	FINAL VELOCITY	TIME	ACCELERATION
a)	20 m s^{-1}	50 m s^{-1}	10 s	-------
b)	100 m s^{-1}	10 m s^{-1}	3 s	-------
c)	0 m s^{-1}	25 m s^{-1}	-------	5 m s^{-2}
d)	48 m s^{-1}	12 m s^{-1}	-------	-3 m s^{-2}
e)	-------	28 m s^{-1}	3 s	7 m s^{-2}
f)	8 m s^{-1}	-------	15 s	6 m s^{-2}
g)	-------	75 m s^{-1}	18 s	3.5 m s^{-2}
h)	9.3 m s^{-1}	-------	12.5 s	6.2 m s^{-2}

12. A trolley takes 7.5 s to reach 6 m s^{-1} from rest. Calculate the acceleration.

13. A bus travelling at 12 m s^{-1} slows to rest in 9 s. Calculate the acceleration.

14. If a ball is travelling at 43 m s^{-1} after accelerating at 10 m s^{-2} for 3 s, what was its initial speed?

15. A boy on a skateboard is travelling at 5 m s^{-1} when he starts down a steep hill and accelerates at 2.3 m s^{-2} for 7 s. What is his final speed?

16. A car decelerates at 1.5 m s^{-2} for 14 s from an initial speed of 27 m s^{-1}. What is the final speed?

17. What is the final speed of a rocket which accelerates at 200 m s^{-1} from rest for 3.5 s?

18. A supertanker travelling at 13 m s^{-1} decelerates at 0.02 m s^{-2}. How long does it take to come to a complete stop?

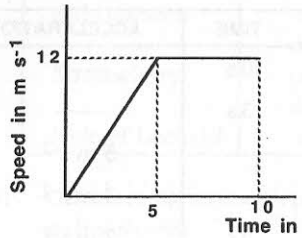
19. A van travelling at 50 km h^{-1} decelerates at 2.5 m s^{-2} to a stop.
a) What is the initial speed of the van in metres per second?
b) How long does it take to come to a stop?

20. What is the initial speed of a car which has accelerated at 3.25 m s^{-2} for 9 s to reach a final speed of 40 m s^{-1}?

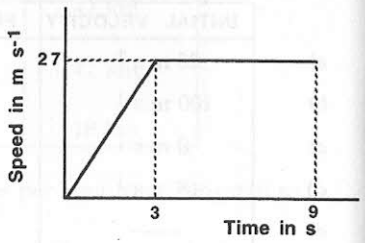
SPEED TIME GRAPHS

21. For each of the following graphs:

a)



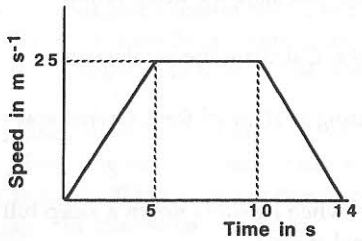
b)



i) calculate the initial acceleration,
ii) calculate the total distance travelled,
iii) calculate the average speed.

22. For each of the following graphs:

a)



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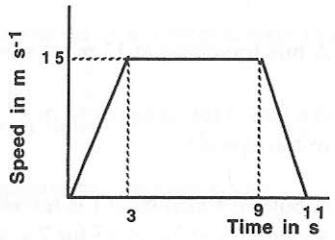
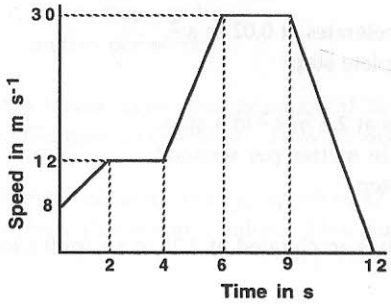


i) calculate the initial acceleration,
ii) calculate the final deceleration,
iii) calculate the total distance travelled,
iv) calculate the average speed.

23. For each of the following graphs:

a)



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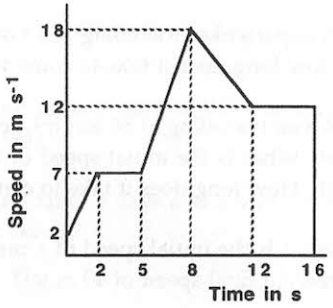
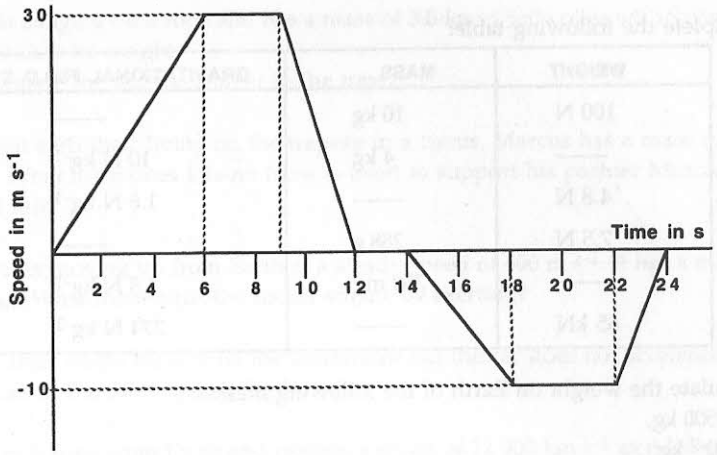


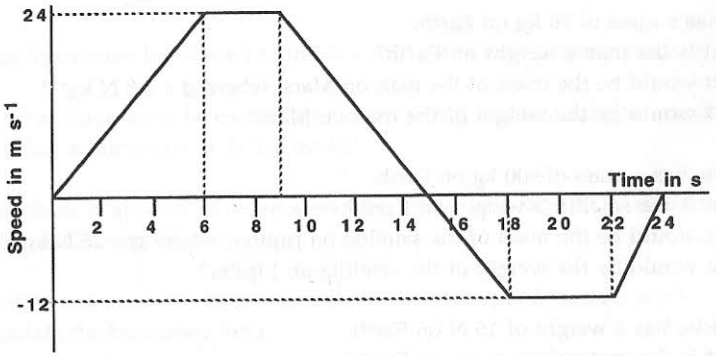
i) calculate the two accelerations,
ii) calculate the final deceleration,
iii) calculate the total distance travelled,
iv) calculate the average speed.

24. *Consider the following graph of the motion of a model car.*



a) Describe the motion of the car between 12 s and 14 s?
b) What can you say about the direction of the motion between 0 and 12 s compared to that between 14 and 24 s?
c) Calculate the initial acceleration.
d) Calculate the deceleration between 9 s and 12 s.
e) Calculate the total distance travelled.
f) Calculate the average speed.
g) How far does the model car finish from the start?

25. *Consider the following graph of the motion of a trolley.*



a) Calculate the initial acceleration.
b) Calculate the deceleration between 9 s and 15 s.
c) Calculate the total distance travelled.
d) Calculate the average speed.
e) How far does the trolley finish from the start?

WEIGHT $W = mg$ (Assume g on Earth is 10 N kg^{-1}.)

26. Complete the following table:

	WEIGHT	MASS	GRAVITATIONAL FIELD STRENGTH
a)	100 N	10 kg	-------
b)	-------	4 kg	10 N kg^{-1}
c)	4.8 N	-------	1.6 N kg^{-1}
d)	7.5 N	288 g	-------
e)	-------	750 mg	3.8 N kg^{-1}
f)	65 kN	-------	274 N kg^{-1}

27. Calculate the weight on Earth of the following masses:
- **a)** 9500 kg,
- **b)** 10^{-7} kg,
- **c)** 27 g,
- **d)** 10^{-3} g.

28. Calculate the mass of objects with weights on Earth of:
- **a)** 787 N,
- **b)** 0.375 N,
- **c)** 1×10^{-4} N,
- **d)** 689 kN.

29. When g varies, is it the mass or the weight which remains constant?

30. A man has a mass of 70 kg on Earth.
- **a)** What is the man's weight on Earth?
- **b)** What would be the mass of the man on Mars, where g = 3.8 N kg^{-1}?
- **c)** What would be the weight of the man on Mars?

31. A satellite has a mass of 900 kg on Earth.
- **a)** What is the satellite's weight on Earth?
- **b)** What would be the mass of the satellite on Jupiter, where g = 26 N kg^{-1}?
- **c)** What would be the weight of the satellite on Jupiter?

32. A meteorite has a weight of 15 N on Earth.
- **a)** What is the meteorite's mass on Earth?
- **b)** What would be the mass of the meteorite on Mars, where g = 3.8 N kg^{-1}?
- **c)** What would be the weight of the meteorite on Mars?

33. An object has a weight of 0.35 N on Earth.
- **a)** What is the object's mass on Earth?
- **b)** What would be the mass of the object on Jupiter, where g = 26 N kg^{-1}?
- **c)** What would be the weight of the object on Jupiter?

NEWTON'S FIRST LAW (Assume g on Earth is 10 N kg^{-1}.)

34. A box is hanging on a rope and has a mass of 3.8 kg.
- **a)** Calculate its weight.
- **b)** Calculate the tension (force) in the rope.

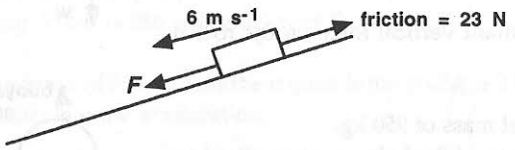
35. Two men earn their living on the trapeze in a circus. Marcus has a mass of 59 kg. What force does Johann have to exert to support his partner Marcus while he is at rest?

36. A rocket is moving up from Earth at a steady speed of 400 m s^{-1}. It has a mass of 2340 kg. What force must the rocket engine be exerting?

37. A car driver keeps his foot on the accelerator but the car does not accelerate, it just continues at the same speed. Explain this.

38. A rocket is fired from Earth and reaches a speed of 12 000 km s^{-1} as it leaves the Earth's gravitational field. Its engine is then switched off as it heads off towards Saturn.
- **a)** What will its speed be in 24 h?
- **b)** Explain your answer to part **a)**.

39. A box slides down a slope at a constant speed as shown. Calculate the value **F**.



40. What force must be exerted to move a 2.6 kg box vertically upwards at 3 m s^{-1}?

41. **a)** What force must be exerted to move a 97.5 g ball vertically upwards at 9.5 m s^{-1}?
- **b)** What assumption is being made?

42. What force is applied to move a mass of 10^7 kg vertically off Earth at a constant speed of 1200 m s^{-1}?

43. A balloon of mass 586 kg moves up at a constant speed of 0.25 m s^{-1}. Calculate the buoyancy force.

44. *A force of 11.5 kN is exerted to move an object vertically upwards at a constant speed of 3.5 m s^{-1}. What is the mass of the object?*

45. *A force of 0.3 N is exerted to move a ball of mass 30 g vertically upwards. If the initial speed is 15 m s^{-1}, calculate the speed 6 s later.*

RESULTANT FORCE (Assume *g* on Earth is 10 N kg^{-1}.)

46. Calculate the resultant force of the following, giving both size and direction of the resultant:

a) 15 N ← □ → 25 N

b) 17 N ← □ → 3 N

c) 9 N ← □ → 12 N

d) 81 N ← □ → 39 N

e) 17 N ← □ → 14 N

f) 9 N ← □ → 4 N, 6 N ↓

47. Calculate the net force of the following, giving both size and direction of the resultant:

a) 15 N ↑, 15 N ← □ → 15 N, 12 N ↓

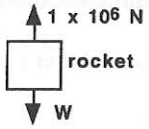
b) 90 N ↑, 71 N ← □ → 71 N, 90 N ↓

c) 12 N ↑, 6 N ← □ → 8 N, 12 N ↓

48. The rocket has a mass of 4 x 10^4 kg.

a) Calculate the weight of the rocket on the Earth's surface.

b) Calculate the resultant vertical force on the rocket.



49. The balloon has a total mass of 950 kg.

a) Calculate the weight of the balloon on the Earth's surface.

b) Calculate the resultant vertical force on the balloon.

NEWTON'S SECOND LAW *F = m a*

50. Complete the following table (1 tonne = 1000 kg):

	MASS	ACCELERATION	FORCE
a)	3 kg	4 m s^{-2}	-------
b)	-------	12 m s^{-2}	6 N
c)	2.5 x 10^3 kg	-------	15 kN
d)	-------	0.6 m s^{-2}	10^4 N
e)	45 mg	-------	1.35 N
f)	75 tonnes	2 x 10^{-3} m s^{-2}	-------

51. A 9500 kg boat accelerates at 45 x10^{-3} m s^{-2}. Calculate the unbalanced force.

52. A force of 16.3 N is applied to a mass of 50 g. Calculate the acceleration.

53. A force of 342 N on an object produces an acceleration of 3.8 m s^{-2}. What is the mass of the object?

54. Calculate the acceleration in the following:

a) 5 N ← □ → 25 N, m = 4 kg

b) 14 N ← □ → 36 N, m = 3 kg

c) 8 N ← □ → 64 N, m = 7 kg

55. Calculate the acceleration in the following:

a) 8 N ← □ → 9 N, 9 N ↓, m = 200 g

b) 3 N ↑, 11 N ← □ → 29 N, 3 N ↓, m = 9 kg

c) 7 N ← □ → 14 N, 9 N ↓, m = 4 kg

56. A force of 10^{-2} N gives an acceleration of 87 m s^{-2}. What is the mass?

57. A trolley of mass 3.2 kg is pulled by a force of 17.5 N but there are frictional forces of 2.3 N acting. What is the acceleration of the trolley?

58. A car has a mass of 750 kg and the engine force acting is 2.5 kN. If the frictional force is 625 N, calculate the acceleration.

59. A toy bus of mass 375 g is accelerating at 2 m s^{-2}. If the frictional force acting is 1.3 N, calculate the applied force?

60. A trolley of mass 6.75 kg is accelerating at 3 m s^{-2}. If the frictional force acting is 3.75 N, what is the applied force?

61. If the frictional force acting on an object is 3.4 kN and the applied force is 7.3 kN, an acceleration of 0.75 m s^{-2} is produced. What is its mass?

62. If the frictional force acting on an object is 0.54 N and the applied force is 0.66 N, an acceleration of 2.4 m s^{-2} is produced. What is its mass?

63. *An elastic applies an average force of 1.5 N to a mass of 0.6 kg and produces an acceleration of 2 m s^{-2}.*

a) What is the frictional force acting?

b) If a second identical elastic is added to the first acting in the same direction, friction remaining constant, what is the resultant force acting?

c) What is the new acceleration?

64. A force of 40 N is applied to a mass of 5 kg and produces an acceleration of 6 m s^{-2}.
   a) What is the frictional force acting?
   b) If a second identical force is added to the first in the same direction, friction remaining constant, what is the resultant force acting?
   c) What is the new acceleration?

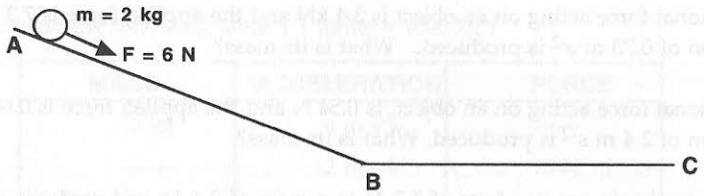
65. A car has a mass of 600 kg while unladen. The driver has a mass of 70 kg and the engine produces a maximum acceleration of 2.4 m s^{-2}.
   a) What is the maximum force exerted by the engine?
   b) The car now picks up three more people and their luggage. The people average 70 kg each. The maximum force can now only produce an acceleration of 1.67 m s^{-2}.
      i) Calculate the total mass of the laden car.
      ii) Calculate the mass of the luggage.

66. A trolley has a mass of 4 kg and a resultant force of 18 N is applied to it.
   a) What is the acceleration produced?
   b) What is the speed after 6 s, starting from rest?

67. A rocket taking off from Earth has a mass of 4.5 x 10^3 kg and the engine force applied is 1 x 10^5 N.
   a) What is the resultant force acting?
   b) What is the acceleration produced?
   c) What is the speed achieved after 5 s, starting from rest?

68. A balloon has a mass of 700 kg and the buoyancy force is 8400 N.
   a) What is the resultant force acting?
   b) What is the acceleration produced?
   c) How long does it take to reach a speed of 12 m s^{-1}, starting from rest?

69. The ball has a resultant force of 6 N acting on it between **A** and **B** as shown. It takes 4 s to reach **B**. Between **B** and **C** there is a frictional force acting and the ball comes to a stop at **C** after a further 3 s.



   a) Calculate the acceleration between **A** and **B**.
   b) Calculate the final speed at **B**, if the ball starts at rest.
   c) Calculate the deceleration between **B** and **C**.
   d) Calculate the frictional force acting.

70. A car of mass 750 kg starts from rest and accelerates at 5 m s^{-2} for 4 s. It continues at a constant speed for the next 6 s and then decelerates to rest in a further 8 s.
   a) Calculate the speed after 4 s.
   b) Draw a speed-time graph for the motion.
   c) Calculate the resultant force acting over the first 4 s.
   d) What is the resultant force between 4 and 10 s?
   e) Calculate the acceleration over the last 8 s.
   f) What is the unbalanced force acting during the last 8 s?
   g) What is the total distance travelled?
   h) What is the average speed?

71. A lorry of mass 2500 kg starts from rest and accelerates at 3.5 m s^{-2} for 6 s. It continues at a constant speed for the next 12 s and then decelerates to rest in a further 14 s.
   a) Calculate the speed after 6 s.
   b) Draw a speed-time graph for the motion.
   c) Calculate the resultant force acting over the first 6 s.
   d) What is the resultant force between 6 and 18 s?
   e) Calculate the acceleration over the last 14 s.
   f) What is the unbalanced force acting during the last 14 s?
   g) What is the total distance travelled?
   h) What is the average speed?

72. A boy picks up a large packing case which has a mass of 80 kg. It starts from rest and reaches a final speed of 0.5 m s^{-1} after 0.8 s. He then continues to lift it at a steady speed of 0.5 m s^{-1}.
   a) What is the initial acceleration of the box?
   b) What is the resultant force on the box while it is accelerating?
   c) What force does the boy have to exert while it is accelerating?
   d) What force does the boy exert when it is moving at a constant speed?

73. A weight-lifter lifts 250 kg at a constant speed of 1.5 m s^{-1}.
   a) What is the minimum force the weight-lifter must exert?
   b) Why must he be able to exert more force than this in practice?

74. a) A rocket has an initial mass of 3 x 10^4 kg and accelerates at 8 m s^{-2}.
      i) What is the resultant force on the rocket?
      ii) What is the force exerted by the engine?
   b) Sometime later, the engine is still producing the same force but fuel has been burnt and the mass has dropped to 2 x 10^4 kg.
      i) What is the new resultant force (assume ***g*** is still 10 N kg^{-1})?
      ii) What is the new acceleration?

75. A rocket has an initial mass of 5 x 10^3 kg and accelerates at 6 m s^{-2}. Sometime later, the engine is still producing the same force but the mass has dropped to 2 x 10^3 kg. What is the new acceleration?