Oxford Resources for IB

Physics – 2023 Edition

Answers

Theme A – Space, time and motion

A.1 – Kinematics

Practice questions – Page 11

1 **a.** 6.3 km

b. 4.5 km

c. 33°

2 **a.** distance = 24 cm, displacement = 21 cm

b. distance = 47 cm, displacement = 30 cm

Practice questions – Page 12

3 15 km h^{-1}

4 8.7 light years

Practice questions – Page 14

5 **a.** 45 km h^{-1}

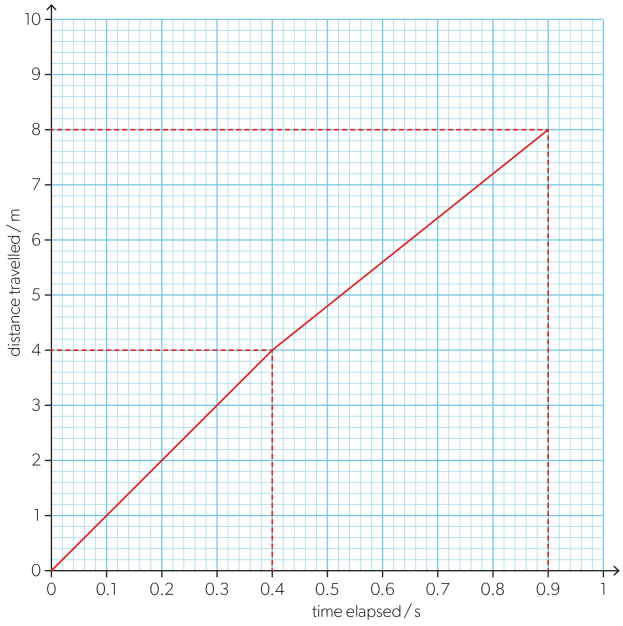
b. 800 m

c. 48 km h^{-1}

6 **a.** **i.** 0.40 s

ii. 8.0 m s^{-1}

b.



Practice questions – Page 16

7 **a.** **i.** approximately 6 m s^{-1}

ii. approximately 2 m s^{-1}

b. 1.9 m s^{-1}

8 **a.** 4.1 m s^{-1}

b. 2.6 m s^{-1}

Practice questions – Pages 21–22

9 C

10 A

11 A

12 B

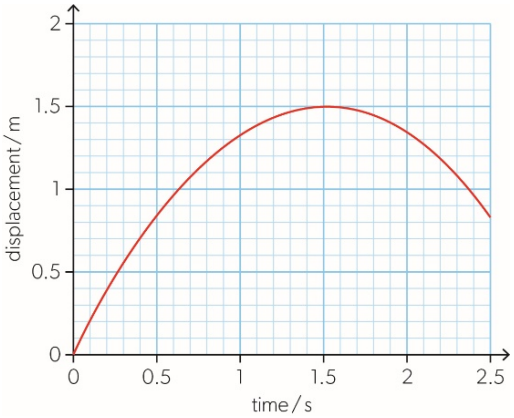
13 **a.** Decelerates from 0 to 1.5 s, changes the direction of motion at 1.5 s and accelerates in the opposite direction from 1.5 s to 2.5 s

b. **i.** −1.3 m s^{-2}

ii. 1.5 m

iii. Answer between 0.80 m and 0.85 m

c.



Practice questions – Page 25

14 **a.** 3.3 s

b. 2.5 m

15 **a.** 1.7 m s^{-2}

b. 1400 m

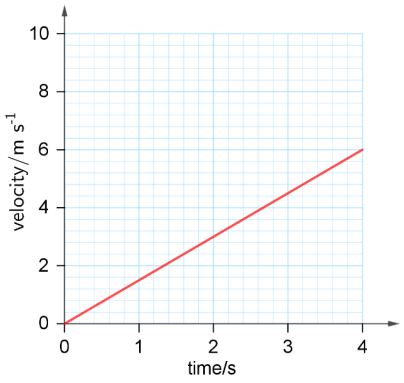
16 19 m s^{-1}

17 **a.** 31 m s^{-1} (110 km h^{-1})

b. 47 s

18 **a.** D

b.



Practice questions – Page 34

19 B

20 D

21 D

22 C

23 **a.** 8.8 m s^{-1}

b. 20 m s^{-1}

c. 26°

d. 4.0 m

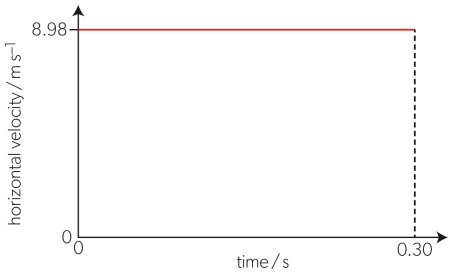
24 19.8 m s^{-1}

25 **a.** $-0.25 = 9.0\sin 4.0° \times t - \frac{1}{2} \times 9.8t^2 \Rightarrow t = 0.299$ s

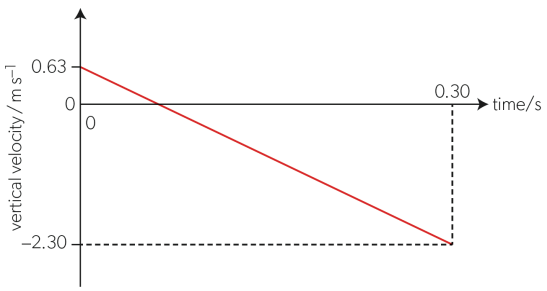
b. **i.** 2.7 m

ii. 9.3 m s^{-1}

c. **i.**



ii.



A.2 – Forces and momentum

Practice questions – Page 46–47

1 D

2 C

3 87 N

4 **a.** 11 kN

b. 1.0 s

5 **a.** 0.29 m s^{-1}

b. 1.2 m

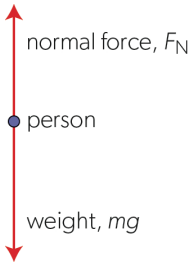
6 **a.** The force acts vertically so it only changes the vertical component of the velocity

b. **i.** 3.4 cm

ii. 15°

Practice questions – Page 52

7



a. 740 N

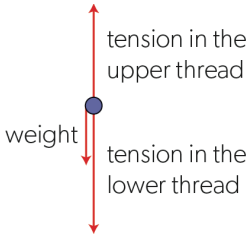
b. 890 N

Practice questions – Page 54

8 **a.** 38 N

b. The vertical component of tension is unchanged (is equal to half the weight of the object) and the horizontal component must increase if the overall force is to make a greater angle with the vertical. Tension in each thread increases so the threads are more likely to break.

9 **a.**



b. Upper thread: 3*Mg*, lower thread: 2*Mg*

10 **a.** **i.** 0.42 N

ii. 0.65 N

b. Moves away from the wall with a constant acceleration, in a straight line along the original direction of the thread.

Practice questions – Page 59

11 A

12 D

Practice questions – Page 61

13 A

14 **a.** 1.25 kg

b. The maximum mass of extra load that can be placed in the container is 5 kg, so the container will not sink.

Practice questions – Page 62

15 0.21 kg m^{-3}

16 **a.** 1.3×10^{-3} N

b. Increases by 8%

Practice questions – Page 67

17 **a.** 3.9 m s^{-2}

b. The maximum acceleration of the box that the static friction force can provide is $0.45g = 4.4$ m s^{-2}. This is greater than the actual acceleration so the box does not slide.

18 5.7 m s^{-1}

19 **a.** 0.069 m s^{-2}

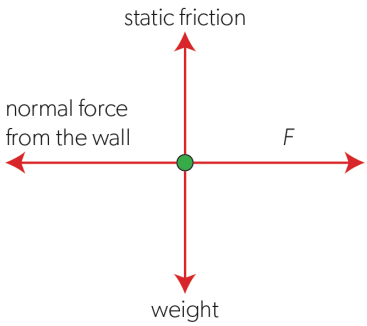
b. 5.1 N

c. 2.8 N

d. 0.15

20 **a.** 16 N

b.



c. 4.9 m s^{-2}

Practice questions – Page 72

21 B

22 C

23 A

24 **a.** Buoyancy and weight remain constant but the drag force in the oil increases with speed, at terminal velocity the net force is zero so the ball no longer accelerates

b. **i.** 2.6×10^{-3} N **ii.** 3.0×10^{-4} N

c. 0.73 m s^{-1}

Practice questions – Page 75

25 **a.** 300 m s^{-2}

b. 120 N

26 **a.** **i.** 0.36 N s

ii. 4.8×10^{-4} s

b. 4.3 cm

c. It assumes that the force on the pellet is constant which in reality may not be the case.

Practice questions – Page 77

27 B

28 D

29 **a.** **i.** 1.5 N

ii. 4.9 m s^{-1}

b. 13 N

Practice questions – Page 79

30 **a.** **i.** 10 kN

ii. 0.25 m s^{-2}

b. The thrust force is constant but the mass of the spacecraft decreases so the acceleration increases.

c. 420 m s^{-1}

d. 18 kg s^{-1}

Practice questions – Page 85

31 **a.** C

b. D

32 A

33 **a.** 8.0 m s^{-1}

b. 12 J

34 **a.** 210 m s^{-1}

b. **i.** 4.0×10^{5} m s^{-2} **ii.** 800 N

35 **a.** 3.0 m s^{-1}

b. K.E. before collision = K.E. after collision = 36 kJ

Practice questions – Page 88

36 **a.** 0.89 m s^{-1}, at 27° to the horizontal

b. KE decreases, inelastic collision

37 **a.** 60 m s^{-1}

b. 41.4°

Practice questions – Page 90

38 **a.** $0.97\ \text{m s}^{-1}$

b. $1.6\ \text{kg m s}^{-1}$ per second

c. The momentum of the water changes so a force is exerted on the water by the hose. From Newton's third law, an equal by opposite force is exerted by the exiting water on the hose. To keep the hose stationary, an external force has to be applied to balance the force exerted by the water.

Practice questions – Page 92

39 **a.** 29 kN

b. The volume of air passing the blades per second is Av so the mass per second is ρAv

c. $16\ \text{m s}^{-1}$

d. $17\ \text{m s}^{-1}$

40 **a.** 0.13 s

b. 0.8 m

Practice questions – Page 96

41 **a.** $1.99 \times 10^{-7}\ \text{rad s}^{-1}$

b. $29.9\ \text{km s}^{-1}$

42 **a.** $70\ \text{rad s}^{-1}$

b. $11\ \text{m s}^{-1}$

Practice questions – Page 97–98

43 C

44 **a.** $310\ \text{km s}^{-1}$

b. $9.9 \times 10^{6}\ \text{m s}^{-2}$

45 **a.** $0.21\ \text{rad s}^{-1}$

b. 14 m

c. $0.63\ \text{m s}^{-2}$

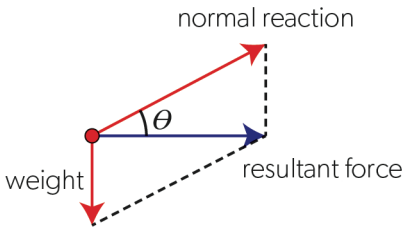
Practice questions – Page 103

46 **a.** $4.8\ \text{rad s}^{-1}$

b. 1.3 s

47 890 m

48 **a.**



b. $\frac{mg}{ma} = \tan\theta \Rightarrow a = \frac{g}{\tan\theta}$

c. **i.** 12 cm

ii. $6.3 \times 10^{-2}\ \text{N}$

d. The centripetal acceleration is constant:

$$\omega^2 r = \frac{g}{\tan\theta} = \text{const}$$

Decreasing the radius implies that the angular speed ω will be increasing.

Practice questions – Page 105

49 **a.** Lowest point, the tension here has a maximum value of:

$$m\frac{v^2}{r} + mg$$

b. **i.** 2.8 m s^{-1}

ii. 4.9 m s^{-1}

50 **a.** $N = m\left(g - \frac{v^2}{r}\right)$

b. **i.** 9.2 kN

ii. 83 km h^{-1}

A.3 – Work, energy and power

Practice questions – Page 111

1 **a.** 0.75 J

b. 0

c. −1.4 J

2 **a.** 830 m

b. 230 N

c. −190 kJ

Practice questions – Page 113

3 **a.** 1.28×10^5 J

b. **i.** 0.75 m s^{-2}

ii. −0.25 m s^{-2}

4 **a.** −15 J

b. 6.25 m

Practice questions – Page 115

5 D

6 D

7 **a.** 4.5 kN

b. **i.** 5.6 × 10^5 J

ii. 5.6 × 10^4 W

c. The driving force is constant but the speed increases, from $P = Fv$ the power must increase

Practice questions – Page 116

8 **a.** 160 kJ

b. 13.9 m s^{-1}

9 **a.** −2.2 J

b. 1.9 m s^{-1}

c. 2.1 m

Practice questions – Page 120–121

10 C

11 C

12 **a.** **i.** 1.44×10^6 J

ii. 1.28×10^6 J

b. The lift force is greater than weight so the helicopter accelerates.
The difference between parts **i.** and **ii.** represents the change in the kinetic energy of the helicopter.

c. 11 m s^{-1}

13 10.4 cm

14 **a.** Final KE = initial KE + loss of GPE, but the loss of GPE only depends on the height travelled and not on the initial angle.

b. 21.2 m s^{-1}

Practice questions – Page 123

15 C

16 B

17 **a.** **i.** 2.0 kN m^{-1}

ii. 0.90 J

b. 4.0 cm

18 **a.** **i.** 1.2 J

ii. 0.30 J

iii. 0.90 J

b. 690 N m^{-1}

c. 49 m s^{-2}, upwards

Practice questions – Page 125

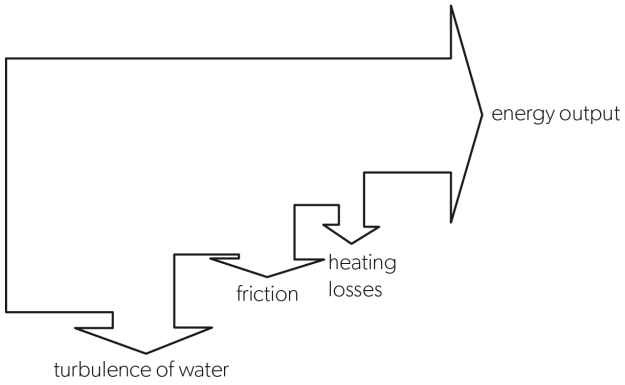
19 77%

20 2.4×10^5 J

Practice questions – Page 128

21 **a.** 53%

b.



A.4 – Rigid body mechanics

Practice questions – Page 133

1 **a.** 0.50 rad s^{-2}

b. 32 revolutions

2 **a.** 900 revolutions per minute

b. 150 revolutions

3 **a.** 1900 rad s^{-2}

b. 0.33 s

4 **a.** 9.5 rad s^{-2}

b. **i.** 4.2 s

ii. 2.7 s

Practice questions – Page 137

5 **a.** Ball A

b. Ball B

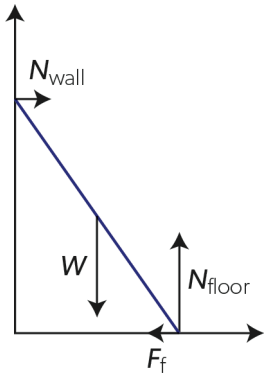
6 A

Practice questions – Page 139

7 **a.** 1.2 kg

b. 26 N

8 **a.**



b. 41 N

c. 0.35

9 **a.** 98 N

b. The vertical component of the tension is less than the weight of the rod hence the force from the wall must have a vertical component to hold the rod in translational equilibrium.

10 D

Practice questions – Page 142

11 B

12 **a.** 75 rad s^{-2}

b. 69 rad s^{-1}

c. 0.92 s

13 **a.** 15 N m

b. 110 N

14 **a.** 0.024 kg m^2

b. 21 revolutions

Practice questions – Page 147

15 **a.** 6.5 J

b. 5.4 m s^{-1}

16 9.5×10^5 N m

17 **a.** 2.6×10^{29} J

b. The assumption in part a. overestimates the moment of inertia hence the actual rotational energy is less than the answer in part **a**.

18 **a.** 170 J

b. 34 W

Practice questions – Page 149

19 B

20 **a.** 22 rad s^{-1}

b. −82 J

Practice questions – Page 154

21 **a.** 4.0 N m s

b. 4800 rpm

22 **a.** 6.5×10^{-4} N m s

b. 4.4×10^{-2} N m

23 **a.** 25 rad s^{-1}

b. The torque is zero so the turntable is in rotational equilibrium

c. 28 revolutions

d. The impulse applied between 8 and 10 s is equal but opposite to the impulse applied between 0 and 1 s.

Practice questions – Page 157–158

24 B

25 **a.** 0.43 m s^{-2}

b. See worked example 23

c. 3.5°

26 **a.** Tension in the thread

b. Hint: consider Newton's second law in the translational and rotational form

c. 1.63 m s^{-2}

d. 1.96 J

27 **a.** 2.4×10^5 J

b. 0.040. Exactly 4% of the total KE of the car is the rotational energy of the wheels.

A.5 – Galilean and special relativity

Practice questions – Page 174

1 **a.** x' = 12.1 km, t' = 0.131 ms

b. x' = 40.4 km, t' = 0.183 ms

2 x = 610 km, ct = 690 m (2 s.f.)

Practice questions – Page 175

3 **a.** 0.9 m

b. 3.8 ns

4. **a.** Hint: (distance according to spacecraft) = (relative speed) × (5.0 years)

b. 0.66c

Practice questions – Page 177

5 **a.** 0.25c

b. 0.27c

6 **a.** 0.40c

b. 0.81c

Practice questions – Page 180

7 5.0×10^{-11} s

8 **a.** 0.966*c*

b. 29.0 m

Practice questions – Page 191–192

9 **a.** **i.** A **ii.** B

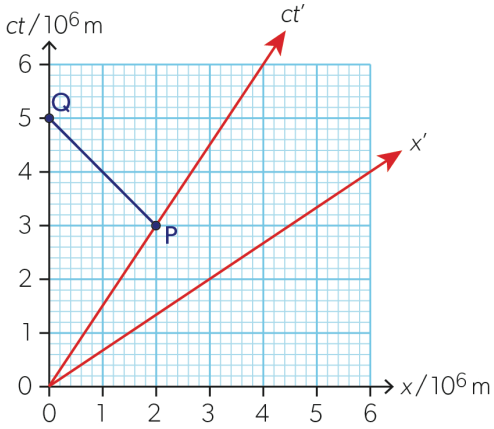
b. **i.** B **ii.** A

10 C

11 D

12 **a.** $\frac{2}{3}c$

b.



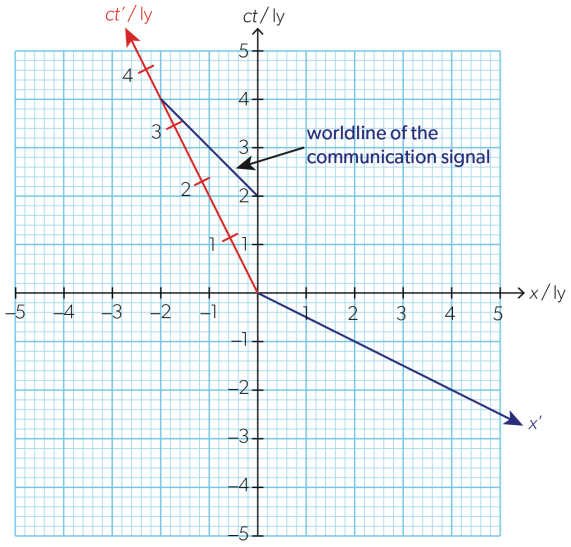
c. **i.** $\frac{2.24 \times 10^{6}\ \text{m}}{c} = 7.45 \times 10^{-3}$ s

ii. $ct' = 6.71 \times 10^{6}$ m, $x' = -4.47 \times 10^{6}$ m

d. **i.** 4.47×10^{6} m

ii. 2.00×10^{6} m

13 **a.**



b. **i.** approximately 3.5 years

ii. 4 years

c. $x' = 0$, $ct' = 3.46$ ly

End-of-theme questions – Pages 194–195

1 **a.** **i.** 150 N

ii. 4800 W

b. **i.** 0.187 s

ii. The height of the ball decreases by 1.63 m during 0.187 s so the height at the net is 1.2 m.

iii. 64.4 m s^{-1}

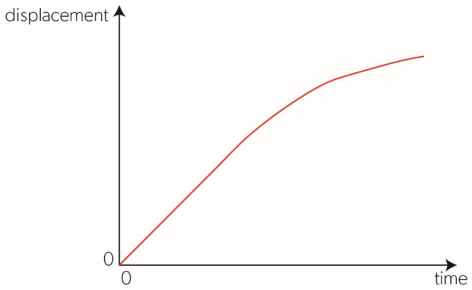
2 **a.** **i.** Hint: elastic energy is the sum of the kinetic and gravitational potential energies of the ice block at C.

ii. 4.9 m s^{-1}

b. **i.** There is zero net force on the block, hence there is constant velocity.

ii. There is a component of weight acting down the slope so the speed decreases.

c.



d. 640 N

3 **a.** **i.** zero

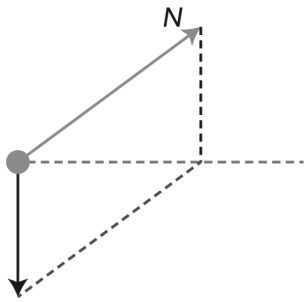
ii. the blades exert a downward force on the air, so the air exerts an equal and opposite force on the blades

iii. 8.1 m s^{-1}

b. 4.6 m s^{-2}

4 **a.** **i.** towards the centre of the circle (horizontally to the right)

ii.



iii. The horizontal component of N provides the centripetal force, so $F = N\cos\theta$.

In the vertical direction, $mg = F\sin\theta$. Combining the equations gives the result.

b. 13 m s^{-1}

c. No, because there is no force to balance the weight.

d. 2.0 m

5 **a.** The torque is 100 N m so the acceleration $\alpha = \frac{\tau}{I} = 0.22$ rad s^{-2}

b. **i.** 1.7 rad s^{-1}

ii. 750 kg m^2 rad s^{-1}

c. 1.3 rad s^{-1}

d. **i.** moment of inertia will decrease and angular momentum will be constant, so the speed will increase ($L = I\omega$).

ii. 131 J

6 **a.** has the same value in all inertial frames

b. **i.** 504 m^2

ii. 7.5×10^{-8} s

c. B measures the proper time, the time is dilated according to A due to its motion relative to B