2.2 Forces

Question Paper

Course	DP IB Physics
Section	2. Mechanics
Topic	2.2 Forces
Difficulty	Hard

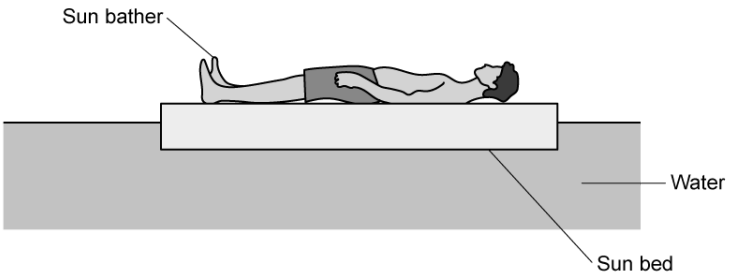
Time allowed: 70

Score: /57

Percentage: /100

Question 1a

A sun bather is supported in water by a floating sun bed.



(a)
Draw and label vectors representing the forces acting on the sun bed.

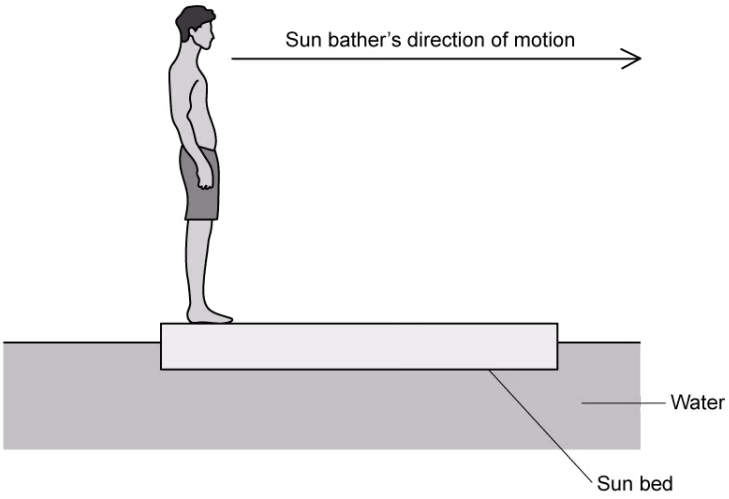
[4]

[4 marks]

Question 1b

The sunbather has incredible core strength and balance.

They stand upright at one end of the sun bed and begin to walk forwards at a constant velocity to the right.



(b)

(i)
Describe the magnitudes and directions of the forces acting between the sunbather and the sun bed

[4]

(ii)
Hence, explain the consequent motion of the sun bed.

[2]

[6 marks]

Question 1c

The sun bed and sunbather may be treated as a single, isolated system.

(c)

(i)
Explain how the sun bed and sunbather may be considered as a 'single' system

[1]

(ii)
Explain how the single system may be considered as 'isolated'.

[1]

[2 marks]

Question 1d

Treating the sun bed and sunbather as a single, isolated system enables quantitative predictions about its centre of mass.

(d)

(i)
State and explain the change in position of the isolated system's centre of mass as the sun bather walks along it

[2]

(ii)
Describe how the motion of the sun bed would change if it had a much larger mass.

[1]

[3 marks]

Question 2a

(a)
Describe the microscopic origin of static friction between two objects.

[2]

[2 marks]

Question 2b

(b)
Compare and contrast the static force of friction and the dynamic force of friction.

[3]

[3 marks]

Question 2c

A block of mass 2.5 kg is at rest on a rough inclined plane. The block just begins to slip down the plane when the angle of inclination is 35°.

(c)
Calculate the coefficient of static friction between the block and the inclined plane.
You may use the following result:

$$\tan\theta = \frac{\sin\theta}{\cos\theta}$$

[3]

[3 marks]

Question 2d

The angle of inclination is increased to 40°.

(d)
Calculate the force that must be applied to the block to move it up the plane with an acceleration of 1.5 m s^{-2}.

Use the following data:

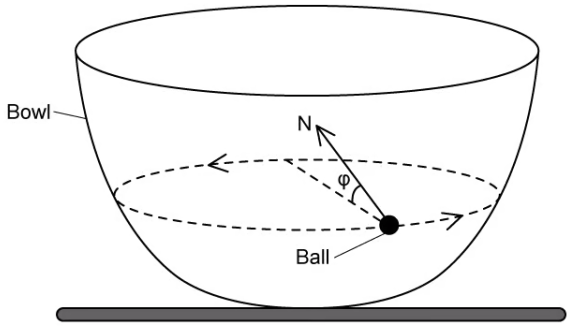
- $\mu_d = 0.30$

[3]

[3 marks]

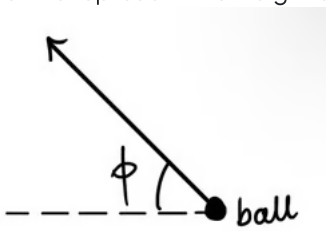
Question 3a

A ball travels in a circular path on the inside surface of a bowl.



The normal reaction force N makes an angle φ to the plane of the ball's path. Ignore the effects of friction.

(a)
On the free-body diagram below, construct an arrow to represent the weight of the ball.



[3]

[3 marks]

Question 3b

(b)
Determine an equation for the resultant force acting on the ball in terms of its mass m and the angle to its plane of orbit φ.

You may use the result:

$$\tan\phi = \frac{\sin\phi}{\cos\phi}$$

[2]

[2 marks]

Question 3c

The radius of the ball's orbit decreases.

(c)
Explain how the effects of friction are related to the decreasing orbital radius.

[3]

[3 marks]

Question 3d

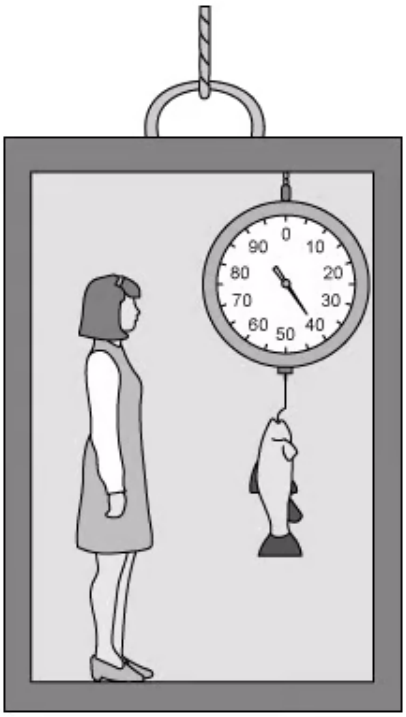
(d)
Outline if the ball could travel along a horizontal circular path with an orbital radius equal to the maximum radius of the bowl. Ignore the effects of friction in your answer.

[3]

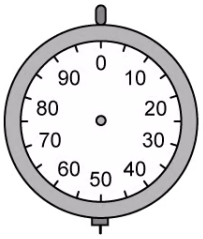
[3 marks]

Question 4a

A woman stands in an elevator and measures the weight of a fish attached to a spring scale. The scale reads 40 N when the elevator is stationary.



(a)
Sketch the reading on the spring scale as the lift gently accelerates upward.



[2]

[2 marks]

Question 4b

As the elevator continues moving upwards, it gently decelerates to a standstill.

(b)
Draw and label a free-body force diagram for the fish as the elevator gently decelerates.

[2]

[2 marks]

Question 4c

The rope that attaches the spring scale to the ceiling of the elevator suddenly snaps. The spring scale and the fish are momentarily in free-fall – but the observer manages to take a reading from the scale it falls.

(c)
State and explain the reading on the spring scale as it falls.

[2]

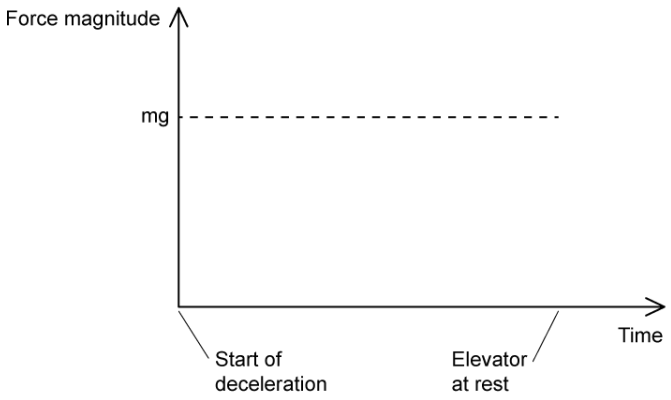
[2 marks]

Question 4d

(d)

Sketch the variation of the contact force on the observer's feet as the elevator decelerates to rest on the axes provided.

The magnitude of the observers weight, *mg*, is included as a dashed line, for reference.

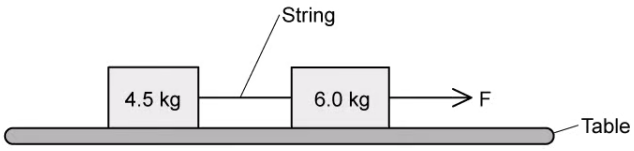


[3]

[3 marks]

Question 5a

Two blocks of mass 4.5 kg and 6.0 kg are joined by a string and rest on a smooth horizontal table. A force *F* of 100 N is applied to one of the blocks.



(a)
Calculate

(i)
The acceleration of the blocks

[1]

(ii)
The tension in the string.

[1]

[2 marks]

Question 5b

The 4.5 kg block is now placed on top of the 6.0 kg block. The coeffecient of static friction between them is 0.40.

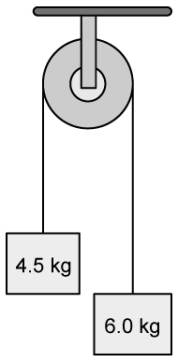
(b)
Calculate the maximum horizontal force *F* that can be applied to the bottom block that would result in both blocks moving together without slipping.

[3]

[3 marks]

Question 5c

The two blocks are now attached by a light inextensible string that passes over a smooth pulley. They are held stationary and suddenly released.



(c)
Determine the acceleration of each block and the tension in the string.

[4]

[4 marks]

Question 5d

The string attaching the blocks over the pulley in part (c) suddenly snaps.

(d)
Describe and explain the subsequent motion of the block of mass 4.5 kg. (Assume it was moving upward at the instant the string snapped).

[2]

[2 marks]