NTU/NUS Prep – Physics
DAY 1

1. A book lies at rest on a table. The table is at rest on the surface of the Earth. The Newton's Third Law reaction force to the gravitational force of the Earth on the book is:
   a. the gravitational force exerted by the Earth on the book.
   b. the normal force exerted by the table on the book.
   c. the gravitational force exerted by the table on the book.
   d. the normal force exerted by the Earth on the table.
   e. the gravitational force exerted by the book on the Earth.

2. Lachlan exerts a constant horizontal force on a heavy lounge chair that is in the wrong place. As a result, the chair moves across a horizontal floor at a constant speed v_0. The constant horizontal force applied by Lachlan:
   a. has the same magnitude as the weight of the chair.
   b. is greater than the weight of the chair.
   c. has the same magnitude as the total force which resists the motion of the chair.
   d. is greater than the total force which resists the motion of the chair.
   e. is greater than either the weight of the chair or the total force which resists its motion.

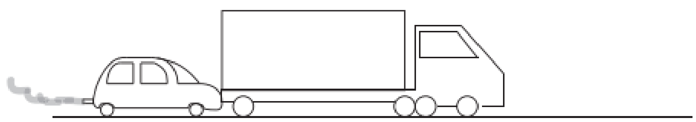
3. If Lachlan, in the previous question, doubles the constant horizontal force that he exerts on the chair to push it on the same horizontal floor, the chair then moves:
   a. with a constant speed that is double the speed v_0 in the previous question.
   b. with a constant speed that is greater than the speed v_0 in the previous question, but not necessarily twice as great.
   c. for a while with a speed that is constant and greater than the speed v_0 in the previous question, then with a speed that increases thereafter.
   d. for a while with an increasing speed, then with a constant speed thereafter.
   e. with a continuously increasing speed.

4. Why does a raindrop fall with near-constant speed during the later stages of its descent?
   a. The gravitational force is constant.
   b. Air resistance just balances the force of gravity.
   c. The height from which the raindrop started falling is fixed in space.
   d. The force of gravity is negligible for objects as small as a raindrop.
   e. Gravity cannot increase the speed of a falling object to more than $9.8\ \mathrm{m\,s^{-1}}$.

5. A glass-walled elevator is moving upwards with constant acceleration. At some point in the elevator's motion, a bolt breaks loose and drops from the ceiling. What is the motion of the bolt as seen by an **external** observer (i.e. one located outside the elevator)?

a. The bolt moves upwards at a constant speed.
b. The bold initially moves upwards, then slows, reverses direction and moves downwards.
c. The bolt appears to remain stationary.
d. The bolt immediately moves downwards, accelerating as it goes.
e. The bolt immediately moves downwards, at constant speed.

6. A large truck breaks down out on the road and receives assistance from a small compact car as shown in the figure below.



The car driver attempts to push the truck with the car. Unfortunately, the truck driver has left the brakes on the truck, and neither vehicle moves. Why does the truck not move?

a. Because the pushing force of the car on the truck is equal to the pushing force of the truck on the car, but in the opposite direction.
b. Because the pushing force of the car on the truck is less than the pushing force of the truck on the car.
c. Because the frictional force of the ground on the truck is equal to the frictional force of the truck on the ground, but in the opposite direction.
d. Because the frictional force of the ground on the truck is greater than the frictional force of the truck on the ground.
e. Because the pushing force of the car on the truck is equal to the frictional force of the ground on the truck, but in the opposite direction.

7. A roller-coaster cart full of water is moving at a constant speed along a horizontal, frictionless length of track. Suddenly, a plug in the bottom of the cart is removed, and the water starts to flow downwards out of the cart. What happens to the speed of the cart while the water is flowing? Ignore air resistance in your answer.

a. The cart speeds up.
b. The cart slows down.
c. The cart speeds up until half the water is gone, then it slows down.
d. The cart slows down until half the water is gone, then it speeds up.
e. The cart's speed does not change.

8. Twins Anna and Tom measure each other's heights each birthday. When they were 12 Anna's height was measured as 151.5 cm and Tom's was measured as 151 cm. On their 16th birthday Anna's height is measured as 167.5 cm and Tom's is measured as 168.5 cm. The uncertainty in the height measurements is 5 mm. Anna and Tom have always been very competitive about their heights, so Tom crows with glee after being measured, saying "Finally, I'm taller than you! We were always about the same height, but now I'm taller than you!" Anna responds, "You're crazy! I was *clearly* taller than you when we were 12." Which of the following statements is most correct?

   a. Tom is probably right and Anna is wrong, they were about the same height at 12, with a difference of 0.5 cm $\pm$ 1.0 cm. Now the measurements show the difference to be 1.0 cm $\pm$ 1.0 cm, more accurate measurements would resolve the dispute over who is taller now.

   b. Tom is probably right and Anna is wrong, they were about the same height at 12, with a difference of 0.5 cm $\pm$ 1.0 cm. Now the measurements show the difference to be 1.0 cm $\pm$ 1.0 cm, however, taking more measurements, regardless of how accurate, couldn't help resolve the dispute over who is taller now.

   c. Tom is right and Anna is wrong, they were about the same height at 12, with a difference of 0.5 cm $\pm$ 0.5 cm. Now Tom is taller by 1.0 cm $\pm$ 0.5 cm.

   d. Anna is right and Tom is wrong, Anna was taller at 12, with a difference of 0.5 cm $\pm$ 0.5 cm. Now Tom is taller by 1.0 cm $\pm$ 0.5 cm.

   e. Anna is right and Tom is wrong, she was 0.5 cm taller than Tom when they were 12. Tom is now 1.0 cm taller than Anna.

9. The long side of a rectangular piece of paper is measured to be (30 ± 2) mm, and the short side is measured to be (20 ± 3) mm. What is the perimeter of this piece of paper, together with its uncertainty?

   a. (50 ± 5) mm

   b. (100 ± 3) mm

   c. (100 ± 5) mm

   d. (100 ± 10) mm

   e. (600 ± 6) mm

10. If a string of linear mass density μ (measured in $\mathrm{kg\,m^{-1}}$) is placed under a tension T (a force, measured in newtons, N), then the fundamental oscillation frequency f (measured in hertz, Hz, equivalent to cycles per second) is related to the length L of the fundamental oscillation mode of the string (measured in metres, m) by $f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$. If you plot a graph with a series of applied tensions (T) on the x-axis, and the square of the length of the fundamental oscillation mode (L^2) on the y-axis, what would you expect to see if the fundamental oscillation frequency is kept constant?

   a. A straight line through the origin, with a positive slope.

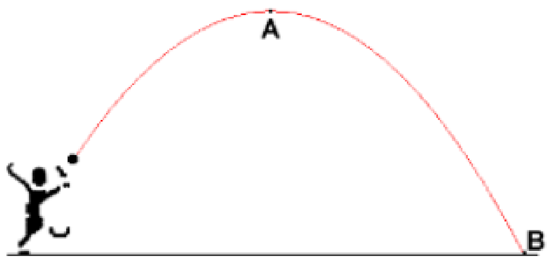
   b. A straight line through the origin, with a negative slope.

   c. A straight line, parallel to the x-axis.

   d. A parabolic curve, with a minimum at $x = 0$.

   e. A parabolic curve, with a maximum at $x = 0$.

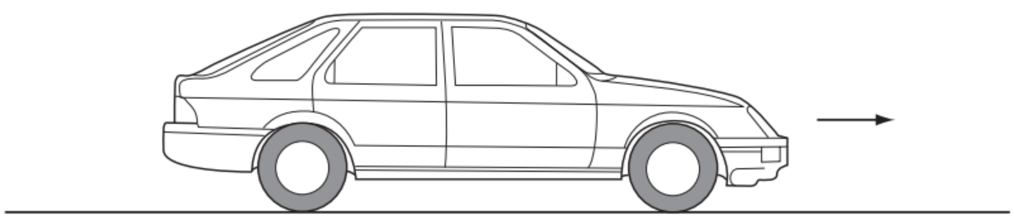
11. A ball is thrown into the air and it moves in the path shown below. Ignore air resistance in this question.



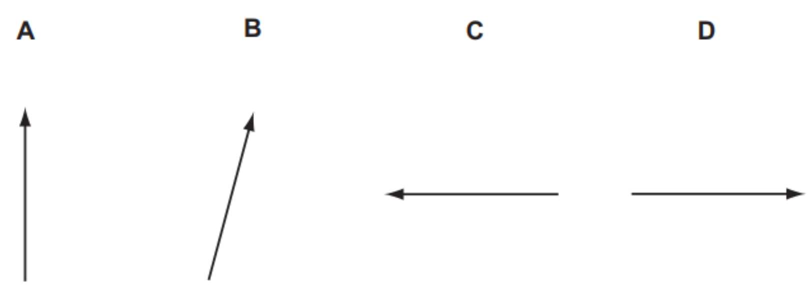
At position A the ball is at the highest point in its path, position B is just before it hits the ground. Which of the following statements is true?

a. The speed of the ball at A is zero and the acceleration of the ball at B is the same as at A.
b. The speed of the ball at A is the same as the speed at B and the acceleration at B is higher than at A.
c. The speed at A is lower than the speed at B and the acceleration at A is higher than the acceleration at B.
d. The speed at A is lower than the speed at B and the acceleration at A is the same as the acceleration at B.
e. The speed at A is higher than the speed at B and the acceleration at A is the same as the acceleration at B.

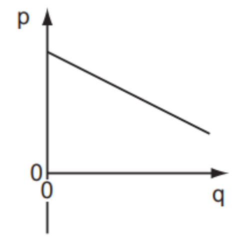
12. A car with front-wheel drive accelerates in the direction shown.



Which diagram best shows the direction of the total force exerted by the road on the front wheels?



13. The graph shows how a certain quantity p varies with another quantity q for a parachutist falling at terminal speed.



What are the quantities p and q, and what is represented by the magnitude of the gradient of the graph?

	quantity p	quantity q	magnitude of gradient
A	height	time	terminal speed
B	momentum	time	weight of parachutist
C	height	potential energy	mass of parachutist
D	velocity	time	acceleration of free fall

14. Four particles, each of charge $+q$, are arranged symmetrically on the x-axis about the origin as shown. A fifth particle of charge $-Q$ is placed on the positive y-axis as shown. What is the direction of the net electrostatic force on the fifth particle?

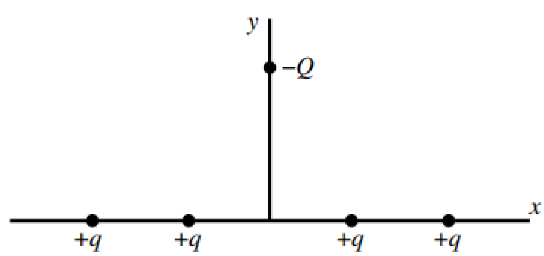
a. ↑

b. →

c. ↓

d. ←

e. The net electrostatic force on the particle of charge $-Q$ is zero.



15. An elevator is rising at constant speed. Consider the following five statements (I to V) about the situation:

I. “The tension in the elevator cable is constant.”
II. “The kinetic energy of the elevator is constant.”
III. “The gravitational potential energy of the Earth-elevator system is constant.”
IV. “The acceleration of the elevator is zero.”
V. “The mechanical energy of the Earth-elevator system is constant.”

Select the correct analysis of this situation out of the options a. to e.

a. Only statements II and V are true.

b. Only statements IV and V are true.

c. Only statements I, II and III are true.

d. Only statements I, II and IV are true.

e. All five statements are true.

16. Bonus ☺

Niamh, the Milo enthusiast, is interested in the physics behind her favourite "energy food drink". To investigate, Niamh prepares to make a huge tank of chocolate milk. Niamh fills the tank of length L and height H with milk, then places a partition a distance L_V along the tank. She adds a large amount of chocolate powder to the milk to the left of the partition as shown in Figure 1 and mixes it thoroughly. The volume of milk to the left of the partition is V_C and the density of this chocolate milk is ρ_C. The remaining volume V_M of plain milk, which has density ρ_M, is to the right of the partition. The chocolate milk is denser than the plain milk.

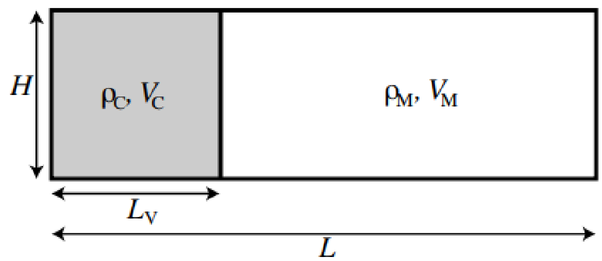


Figure 1: Tank containing chocolate milk and plain milk. View from side.

The partition is removed extremely quickly. **To begin with, it is assumed the chocolate milk does not mix with the plain milk.**

a) Draw a diagram of the contents of the tank a long time after the partition has been removed. Use the space provided on p. 2 of the Answer Booklet.

Upon removing the partition Niamh observes that the chocolate milk spreads through the tank like a wave. She constructs a basic model of the chocolate milk wave in order to find out how quickly it travels. She divides the chocolate milk behind the partition into two equal sections. When the partition is removed, the bottom section is displaced by the top section and begins to move with velocity U. This process is depicted in Figure 2.

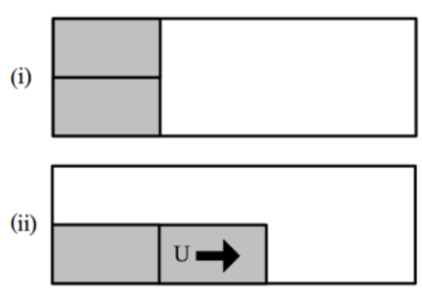


Figure 2: Niamh's model of the chocolate milk wave. (i) Before the partition is removed. (ii) after the partition is removed.

b) Find U.