THE UNIVERSITY OF NEW SOUTH WALES
SCHOOL OF PHYSICS

PHYS1131
HIGHER PHYSICS 1A

TEST 1
SESSION 1, 2000

Time Allowed: 1.5 hours

Family Name	Initials
Print	
Student ID	
Signature	

Question	Mark
1	
2	
3	
4	
5	
6	
TOTAL	

INSTRUCTIONS

1. **Do not read or write on this paper until instructed to do so.**
2. For each test attempted, answer all questions.
3. Answer questions in the spaces provided.
4. Questions are not necessarily of equal value.
5. For each question, full working and explanation must be shown.
6. Answers must be written in ink. Pencil may only be used for drawings, sketching or graphs.
7. Portable, batter powered electronic calculators will be supplied.
8. **This booklet must be handed in at the end of the examination.**

QUESTION 1 **[Marks 14]**

All streets in a suburb run north-south or east-west. A person wants to drive from point A to point B which is a direct distance of 15 km in direction 75° east of north. The legal speed limit is 60 km/h.

(a) (i) Draw a vector diagram showing the displacement vectors along streets which would take the person from A to B.

(ii) Determine the minimum time in which a person can legally drive from A to B.

(b) A car is driven due north at a constant speed of 33 m s^{-1} relative to the ground. Rain is falling. The rain is driven towards the north by a wind that is blowing due north. A person standing on the road sees the path of the rain drops making an angle of 22° to the vertical. The rain drops appear to the driver of the car to be falling vertically.

(i) Draw a vector diagram showing the relation between the velocities of the car and the rain relative to the ground and the velocity of the rain relative to the car.

(ii) Determine the velocity of the raindrops relative to the ground.

QUESTION 2 **[Marks 17]**

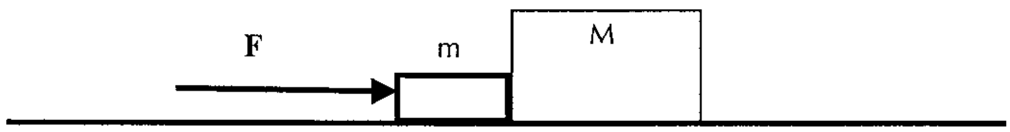
Two blocks of mass m = 1.3 kg and M = 3.7 kg are in contact on a frictionless horizontal table as shown. A horizontal force **F** = 6.0 N is applied to the mass m.

(a) (i) Determine the acceleration of the two blocks.

(ii) Sketch the diagram and draw on it all the forces acting on block *m* and all the forces acting on block *M*.

(iii) Determine the $\mathbf{F}_m$, the force of block *m* acting on block *M*.

(iv) Determine the $\mathbf{F}_M$, the force of block *M* acting on block *m*.



(b) A 2000 kg jet engine is attached to the wing of a plane by just three bolts. The plane is travelling along a level path at a constant speed of 800 km h^{-1} when it encounters sudden turbulence that imparts an upward acceleration on the plane of 1.7 m s^{-2}.
Determine the force (magnitude and direction) on each bolt.

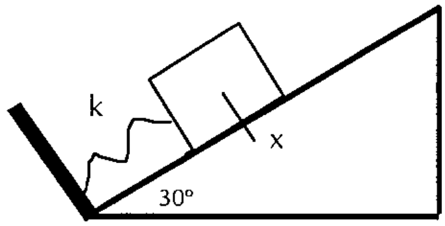
(c) A 60 kg person is standing on a frictionless ice surface 11 m away from a 15 kg sled. The person pulls the sled towards themselves with a rope.

(i) Determine the distance from the initial position of the person that the sled and person meet.

(ii) If the acceleration of the person toward the sled is 0.1 m s^{-2}, determine the acceleration of the sled.

QUESTION 3 **[Marks 10]**

A 5.0 kg block is placed against a light spring on a frictionless inclined plane. The spring is compressed by $x = -120$ mm from its unstretched position on the plane at $x = 0$ and then released. The spring has a spring constant $k = 2500$ N m^{-1}.



(a) (i) Write down the potential energy of the spring as a function of x.

(ii) Choosing the zero of the gravitational potential energy to be at $x = 0$, write down the gravitational potential energy as a function of x.

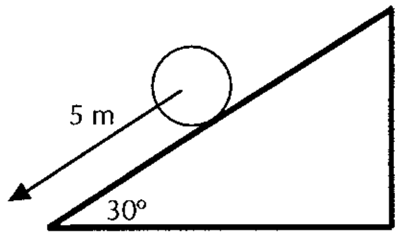
(b) Determine the velocity of the block at $x = 0$ where the spring is unstretched.

QUESTION 4 **[Marks 16]**

(a) Two discs are mounted on the same frictionless axis. They can rotate independently but they can also be brought together so that they rotate together as a single unit.
Disc A has a moment of inertia of $I_A = 2.5$ kg m^{-2}. Disc B has a moment of inertia of $I_B = 5.0$ kg m^{-2}. Initially Disc A is rotating at 900π rad s^{-1} and disc B is rotating at 1800π rad s^{-1} in the opposite direction.

(i) If the two discs are coupled together, determine their angular speed afterwards.
(ii) What fraction of the initial rotational kinetic energy is lost when the two discs couple.

(b) A solid cylinder of radius r = 0.05 m and mass m = 0.9 kg starts from rest and rolls without slipping a distance of 5 m as shown down a plane that is inclined at 30° to the horizontal.
The moment of inertia of a uniform cylinder of mass M and radius R is $\frac{1}{2}MR^2$.



(i) Determine the final total kinetic energy of the cylinder.
(ii) Determine its final translational kinetic energy.
(iii) Determine its final rotational kinetic energy.

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QUESTION 5 [Marks 12]

A 60 kg person places a 4.0 m ladder of mass 12 kg against a smooth vertical wall with the foot of the ladder 1.5 m from the wall. He/she climbs 3.0 m along the ladder. The ladder does not move.

(a) Draw a sketch identifying all the forces acting on the ladder

(b) Determine the force (direction and magnitude) exerted by the wall on the ladder.

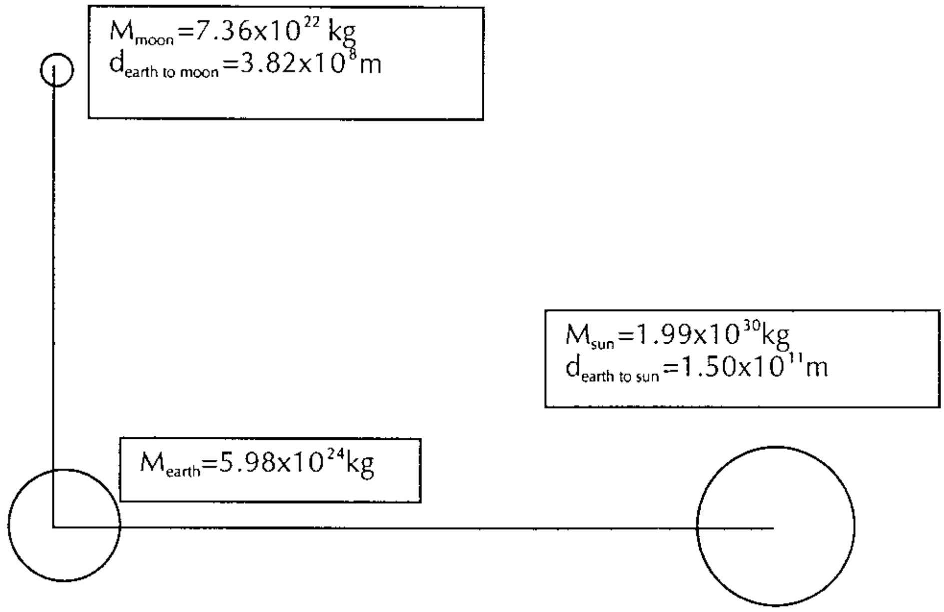
(c) Determine the force (direction and magnitude) exerted by the ground on the ladder.

(d) Determine the minimum value of the static coefficient of friction μ_s between the ground and the ladder.

QUESTION 6 **[Marks 11]**

(a) Calculate the height above the earth's surface at which the acceleration due to the earth's gravity is $g = 7.4\ \text{m s}^{-2}$.

(b)



At a certain moment the sun and the moon are aligned with the earth as shown.
Distances between the bodies (d) and the masses (M) are given on the diagram, which is not to scale.

(i) Sketch a vector diagram showing the directions of the gravitational forces acting on the earth due to the moon and due to the sun.

(ii) Determine the magnitude and direction of the total gravitational force acting on the earth due to the sun and the moon.