FIRST YEAR PHYSICS
SELF-DIAGNOSIS EXERCISES
Mechanics - 1. Forces
(for PHS1011/ENG1802)

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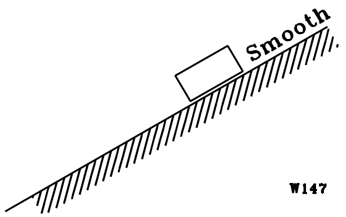
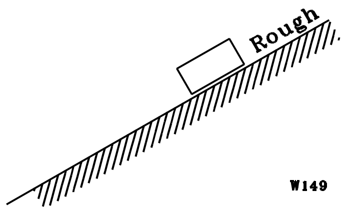
Designed to overcome weaknesses in basic concepts of Year 11/12 physics.
For your own benefit, attmpt questions before looking at answers on right side of page.

QUESTIONS

For each of the following questions (1 - 4) draw vectors to represent the forces which are acting on the object and describe the nature of the forces.



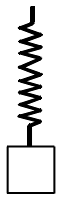
W147



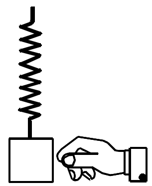
W149

1. A block sliding down a smooth plane.

2. A block sitting at rest on a rough inclined plane.



W151



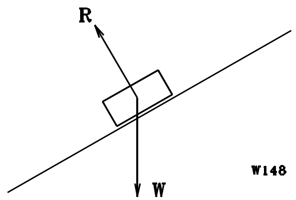
W153

3. A mass hanging at rest on the end of a spring.

4. A mass on the end of a stretched spring just after being released.

ANSWERS

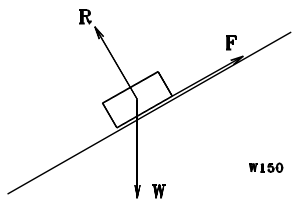
1.



W148

Here the weight force W is directed vertically down but the normal reaction force R is perpendicular to the inclined plane (Remember that "normal" means "perpendicular").
In this case the forces cannot cancel (the sum of the two vectors cannot be zero). There is an unbalanced force and as you will learn later this causes the body to accelerate down the slope.

2.

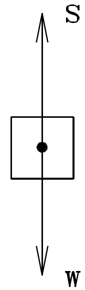


W150

In addition to the weight and the normal reaction force there is a friction force acting on the body directed up the slope. Because the body is at rest these three forces must balance. Remembering what you have learnt about summing vectors by arranging them tip to tail you can see that the three vectors must form a closed triangle.

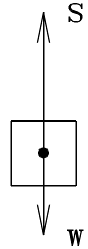
Note that with a smaller frictional force the forces would not balance (the vectors would not form a closed triangle) and the block would accelerate down the slope. You will learn later how to calculate the resulting acceleration from the unbalanced force.

3. This is a very similar situation to that of question 4. Here the extended spring is exerting an upward pull on the ball. This force S is equal and opposite to the weight force W since the mass is at rest, therefore there is no unbalanced force on it.



W152

4. Here the spring is stretched more than in the previous question and the force F is
greater than W. There is therefore an unbalanced force and the mass is accelerated upwards.

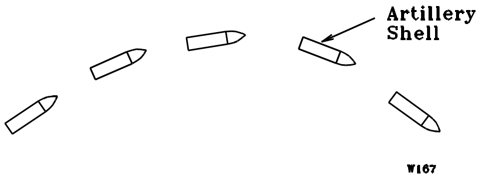


W154

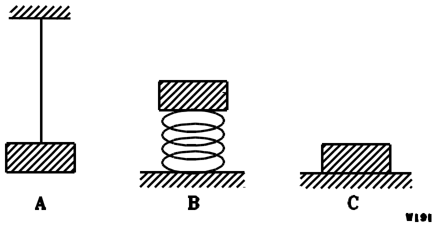
Remember that a force is not needed to cause motion.
Forces are needed only to change motion.

QUESTIONS

5. An toy rocket at various positions along its path. Mark in the forces for each position of the rocket. (Assume that there is no friction force due to the atmosphere.)



6. The figure shows a block of weight W Newton in three situations. In A it is hanging on a string, in B it is resting on a compression spring which is sitting on the floor and in C it is sitting directly on the floor. In all cases the block is at rest.



For the following cases, describe in words the nature of the force on the block which opposes weight W:

(a) Case A.

(b) Case B.

(c) Case C.

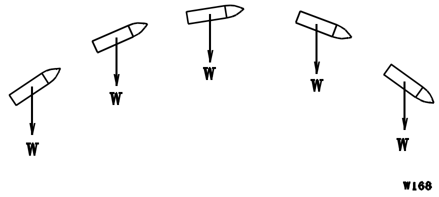
The next part of the question is concerned with Newton's Third Law which is often stated "For every action there is an equal and opposite reaction".
Regarding the weight W of the block as the "action" force describe in words the nature of the "reaction" force for:

(d) case A

(e) case B

(f) case C

ANSWERS



5. The only force acting is the weight force W. If you have a force in the direction of motion, this is a common misunderstanding : "a force is required to keep a body moving" seems to occur in everyday motion because of friction, so we have to apply a force to overcome friction and keep objects moving. In the absence of friction however, a body would continue moving with uniform speed when no forces were acting on it, and accelerates if there is a net force.

6.(a) The force exerted by the string usually called the "tension in the string". This is the type of force which you feel when you stretch a rubber band. The topic of tension is discussed in Question 7.

(b) The force exerted by the compressed spring. This is the type of force which you feel when you squash a tennis ball. Both this and the tension force of question (a) are associated with the deformation (change of shape) of a solid material.

(c) The force exerted by the floor. Case C is similar to case B: the floor will squash down under the block like the spring in case B or the squashed ball. The movement of the floor will be very small. The force related to this deformation is often called the *normal* force. Note that here the word "normal" means "perpendicular" not "usual".

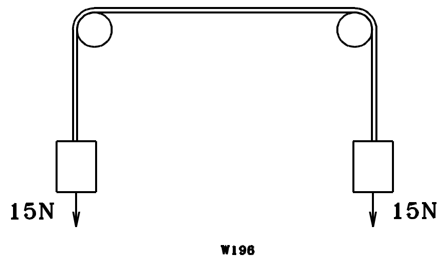
(d) The gravitational force exerted BY the block ON the earth. Remember, the "action-reaction" pair of Newton's Third Law involves two bodies, say X and Y. If the "action force" is exerted by body X on body Y then the "reaction force" is the force exerted by body Y on body X. Here, the "action force" is the gravitational force exerted by the earth on the block (two bodies). The "reaction force" is the gravitational force exerted by the block on the earth.

(e) The gravitational force exerted BY the block ON the earth. This is the same situation as (d). The two bodies involved are the block and the earth.

(f) The gravitational force exerted BY the block ON the earth. This is the same situation as (d),(e). The two bodies involved are the block and the earth. You may have said that the "reaction force" was the force exerted by the floor on the block. This is a common error since the term "normal reaction force" is used to describe this force and "reaction" is used in the statement of Newton's 3rd Law.

QUESTIONS

7. The figure shows a string passing over smooth pulleys with weights attached to each end.



(a) What is the tension in the horizontal section of the string?

(b) What is the tension in the vertical section of the string?

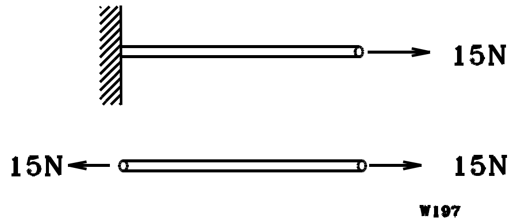
8. Consider an object of mass 2 kg "colliding" (i.e. interacting) with a device which exerts a constant force of 20 N on it for a period of 4 s.

(a) What is the magnitude of the impulse of this force?

(b) If the initial velocity of the object was +50 m s^{-1} and the force was negative (i.e.in the direction opposite to the initial direction of motion), what is the velocity of the object after the collision?

(c) If the initial velocity of the object was +15 ms^{-1} and the force was in the direction opposite to the initial direction of motion, what is the velocity of the object after the collision?

ANSWERS



7.(a) 15 N. As far as the string is concerned this situation is no different from the cases shown in the figure, the free end of a string attached to a wall being pulled with a force of 15 N or a string being pulled at both free ends with a force of 15 N. Remember that since the string or any portion of it is at rest there must be equal and opposite forces on <u>each</u> end of it.

(b) 15 N. As explained above the tension is the same throughout the string.

9.(a) The magnitude of the impulse is $F\Delta t = 80$ N s $= 80$ kg m s^{-1}.
Note the alternative but equivalent form of units, N s corresponding to force × time and kg m s^{-1} corresponding to mass × velocity i.e. momentum.
Note that the word "interaction" was used as an alternative to "collision". It is not necessary that a "collision" should be a short sharp process. The "collision" of a space craft with a planet may involve only a spell in the planet's gravitational field and not a crash on the planet's surface.

(b) +10 m s^{-1}. The impulse is -80 N s and this causes a change in momentum $m(v_f - v_i)$, where v_i and v_f are the initial and final velocities respectively.
Thus $-80 = 2(v_f - 50)$ and $v_f = +10$ m s^{-1}.
Here the impulse has opposed the motion and slowed down the ball.

(c) -25 m s^{-1}. The impulse of -80 N s causes a change in momentum $m(v_f - v_i)$.
Thus $-80 = 2(v_f - 15)$ and $v_f = -25$ m s^{-1}.
Here the impulse has opposed the motion and caused the ball to reverse its direction of motion and leave the device with an increased speed.