Problems for chapter 5.

Revision: $\sum \mathbf{F} = m\mathbf{a}$ If there is no rotation the forces can be taken to act through the centre of mass.

The work done by a force is found from the area under the force vs distance graph.

$\frac{1}{2}mv^2 - \frac{1}{2}mv_0^2 = F(s - s_0)$ for a force that causes motion.

$\frac{1}{2}mv^2 - \frac{1}{2}mv_0^2 = mg(y_0 - y)$ in this case $y > y_0$.

$P = \dfrac{W}{t} = Fv$

1.*A hammer thrower releases the ball at the end of the hammer with a speed of 35.0 m s^{-1}. If the ball is 2.10 m from the axis about which her body turns, and has a mass of 4.00 kg, what magnitude of radial force must the thrower overcome to hold the ball as she turns in the circle?

2. A discus thrower releases the disc with a speed of 25.0 m s^{-1}. If the discus is 1.20 m from the axis about which his body turns, and has a mass of 2.00 kg, what magnitude of radial force must the thrower overcome to hold the disc as he turns in the circle?

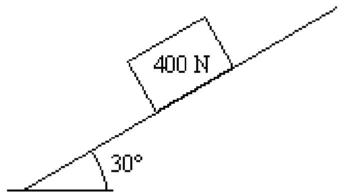
3.* If a car with a speed of 16.7 m s^{-1}, turns a corner of radius 34.7 m what friction force is required from the tyres to hold the car on the road? (The car has a mass of 1050 kg.)

4. If a racing car with a speed of 24.0 m s^{-1}, turns a corner of radius 36.0 m what friction force is required from the tyres to hold the car on the road? (The car has a mass of 1050 kg.)

5.* A helpless traveler of mass 60.0 kg is sliding along a frozen river towards a frozen waterfall with a speed of 0.80 m s^{-1}, the traveler is sitting on a 20.0 kg sledge that moves across the ice with no friction. Just in time the traveler comes to his senses and jumps off the sledge, after this jump he moves at 0.50 m s^{-1} from the waterfall (icefall really). show that the sledge and the traveler experience opposite and equal forces. If you can't do this assume that it takes half a second for the traveler to push off from the sledge.

6. A traveler of mass 60.0 kg is sliding along a frozen river towards a frozen waterfall with a speed of 0.80 m s^{-1}, the traveler is sitting on a 20.0 kg sledge that moves across the ice with no friction. In desperation the traveler thinks to fire some rifle bullets in the direction that the sledge is running. These bullets each have a mass of 50×10^{-3} kg and a muzzle speed of 500 m s^{-1}. Each bullet accelerates from rest in the rifle to the 500 m s^{-1} over a distance of 0.90 m, if the acceleration is constant, how long does this take? What average force acts on the traveler and sledge while this takes place?

7.* A block slides down a plane that is inclined to the horizontal by 30°, if there is no friction what is the acceleration of the block? Now if the weight of the block is 400 N what is the normal force that acts directly into the plane and what is the component of the weight force that acts directly down the plane? Finally, if a friction force of 20 N acts directly up the plane what is the new acceleration of the block?

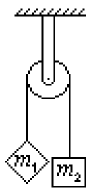


8. If the block shown above and described in question 7., does not slide at all what frcition force is required to hold it in position? What is the acceleration of the block if the friction has eactly one half this value (that is needed to hold the block in place)?

9.* The 400 N block (shown above) is pulled up a 30° plane by a force that acts directly up the plane and the friction force that resists the motion is 20 N. What is the magnitude of this pulling force if the block moves upwards without acceleration? What is the magnitude of this pulling force if the block moves with an acceleration of 1.0 m s^{-2} up the plane? If the force is not strong enough to move the block up the plane it may still slide down, what is the magnitude of the force if the block slides directly down the plane with an acceleration of 1.0 m s^{-2}?

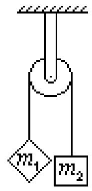
10. The 400 N block (shown above) is pulled up a 30° plane by a force that acts directly up the plane and the friction force that resists the motion is 15 N. What is the magnitude of this pulling force if the block moves upwards without acceleration? What is the magnitude of this pulling force if the block moves with an acceleration of 1.0 m s^{-2} up the plane? If the force is not strong enough to move the block up the plane it may still slide down, what is the magnitude of the force if the block slides directly down the plane with an acceleration of 0.5 m s^{-2}?

11.*



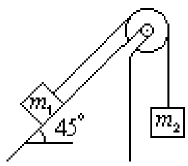
Two block are suspended by a light unstretching cord that passes around a light frictionless pulley. If m_1 = 1.00 kg and m_2 = 1.05 kg what is the rate at which they will accelerate when they are released and what is the tension in the cord? What support force is needed from the ceiling to hold this system while the blocks accelerate? Remember that the pulley the cord and the support have no effective mass.

12.



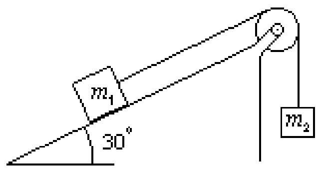
Two block are suspended by a light unstretching cord that passes around a light frictionless pulley. If m_1 = 0.90 kg and m_2 = 1.10 kg what is the rate at which they will accelerate when they are released and what is the tension in the cord? What support force is needed from the ceiling to hold this system while the blocks accelerate? Remember that the pulley the cord and the support have no effective mass.

13.*



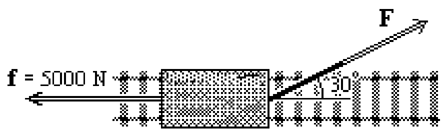
The same two blocks of question 11. are now placed in the <u>frictionless</u> system shown above (the pulley still has no effective mass). Find the magnitude of the acceleration of each block. Is it possible for m_1 to be greater than m_2 and yet still have m_2 accelerate downwards?

14.



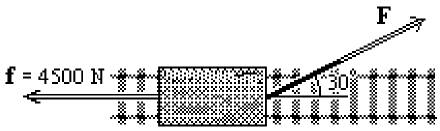
The same two blocks of question 13. are now placed in the <u>frictionless</u> system shown above (the pulley still has no effective mass). Find the magnitude of the acceleration of each block. Is it possible for m_1 to be greater than m_2 and yet still have m_2 accelerate downwards?

15.*



A railway waggon of mass 12000 kg is pulled along the railway track by a force applied at 30° to the track, the frictional resistance is 5000 N. If the waggon does not accelerate how much work is done to pull the waggon 2.5 m along the track? If the force has a component of 6000 N along the track what is the change in kinetic energy after the force has accelerated the waggon through 2.5 m? What is the magnitude of the force **F**?

16.



A railway waggon of mass 15000 kg is pulled along the railway track by a force applied at 30° to the track, the frictional resistance is 4500 N. If the waggon does not accelerate how much work is done to pull the waggon 3.5 m along the track? If the force has a component of 7500 N along the track what is the change in kinetic energy after the force has accelerated the waggon through 3.5 m? What is the magnitude of the force **F**?

17. Use the energy equation

$$\tfrac{1}{2}mv^2 - \tfrac{1}{2}mv_0^2 = mg(y_0 - y)$$

to show that in the absence of air resistance an object thrown vertically up into the air returns to the same height with the opposite velocity to that with which it was released.

18.* An object is thrown horizontally from a cliff with a speed of 10 m s^{-1}. Use the energy equation to find the speed with which it is falling after it has fallen 40 m.

19.* Two pucks slide over a frictionless surface and collide, both have the same mass of 0.25 kg. One is traveling with a velocity of 11.0 m s^{-1} in the positive x-direction while the other has a velocity of 8.0 m s^{-1} in the negative x-direction. If they meet head on and return along the x-axis and they lose 10% of their kinetic energy in the collision what are their final speeds?

20. Two pucks slide over a frictionless surface and collide, both have the same mass of 0.25 kg. One is traveling with a velocity of 12.0 m s^{-1} in the positive x-direction while the other has a velocity of 7.0 m s^{-1} in the negative x-direction. If they meet head on, lock together and return along the x-axis how much kinetic energy is lost in the collision?

21. Rub your hand backwards and forwards along the edge of your table with a speed as near to 0.5 m s^{-1} that you can judge. Now rub faster, with the same pressure as before, and convince yourself that the power required to overcome friction could be found from the formula $P = Fv$.