WORK.ENERGY.POWER

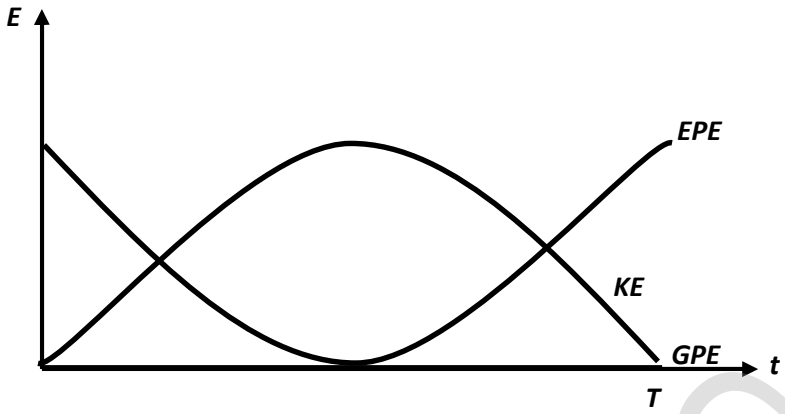
Challenging **MCQ** questions by The Physics Cafe

Compiled and selected by The Physics Cafe

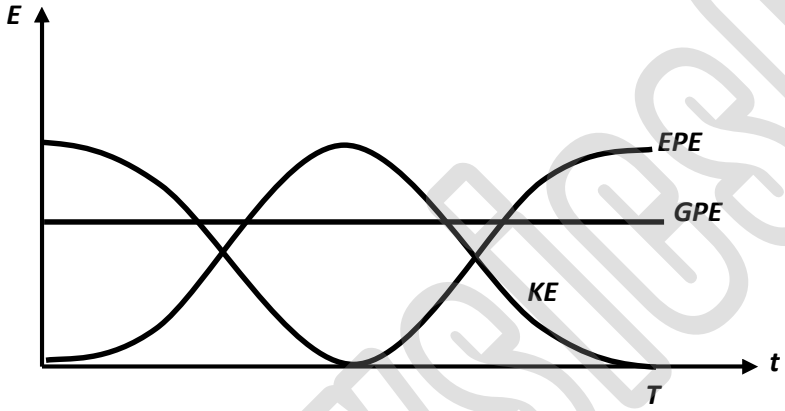
1 A mass on a smooth horizontal table is attached by two light springs to two fixed supports. The mass executes linear simple harmonic motion.

Which of the graphs correctly show how the kinetic energy (*KE*), elastic potential energy (*EPE*) and gravitational potential energy (*GPE*) would vary with time?

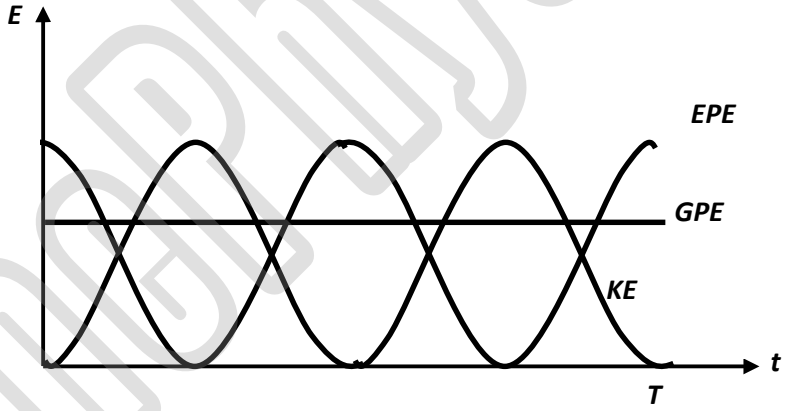
A



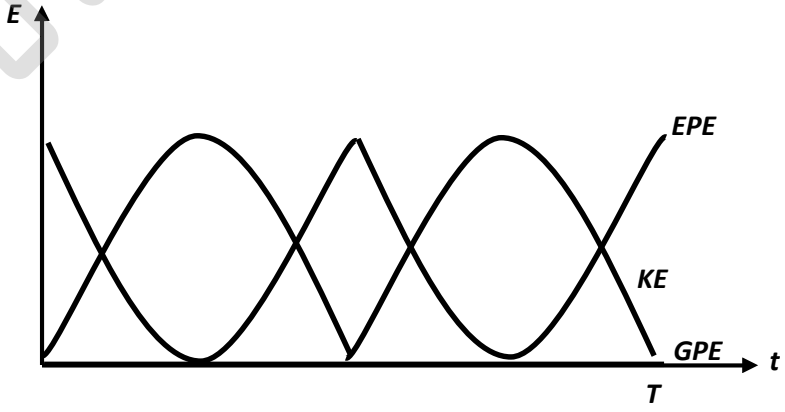
B



C



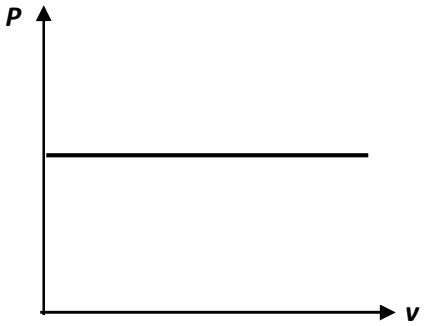
D



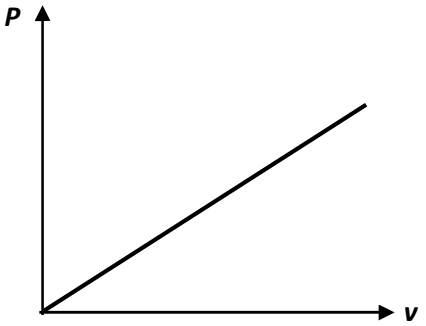
2 A car moving through air at velocity v experiences a resistive force F given by the expression $F = kv^2$ where k is a constant.

Which of the following graphs show how the power supplied to the car P will vary at various v to ensure that the car is moving without any acceleration?

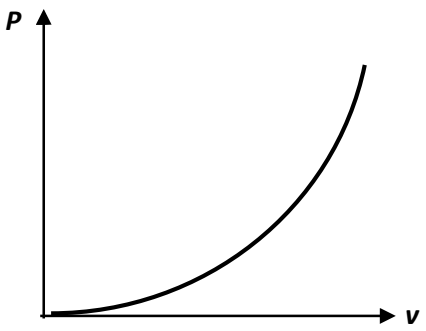
A



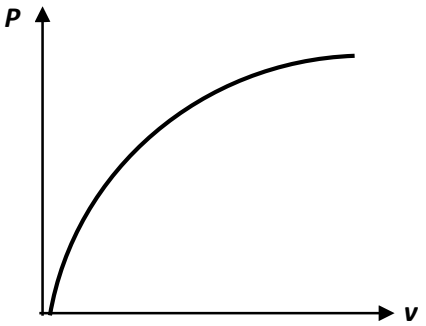
B



C



D



(ACJC, 2014)

3 A wind turbine has blades that sweep an area of 2000 m^2. It converts the power available in the wind to electrical power with an efficiency of 50%.

What is the electrical power generated if the wind speed is 10 m s^{-1}?

(The density of air is 1.3 kg m^{-3}.)

A 130 kW **B** 650 kW **C** 1300 kW **D** 2600 kW

4 A man lifts a 10 kg sack of rice from a ground to above his head using his both hands. The sack of rice does not experience a change in kinetic energy between the two positions. Which of the following statement is correct?

A The work done on rice sack by gravity is less than the work done on rice sack by man.

B The work done on rice sack by gravity is more than the work done on rice sack by man

C The work done on rice sack by gravity is equal to the work done on rice sack by man.

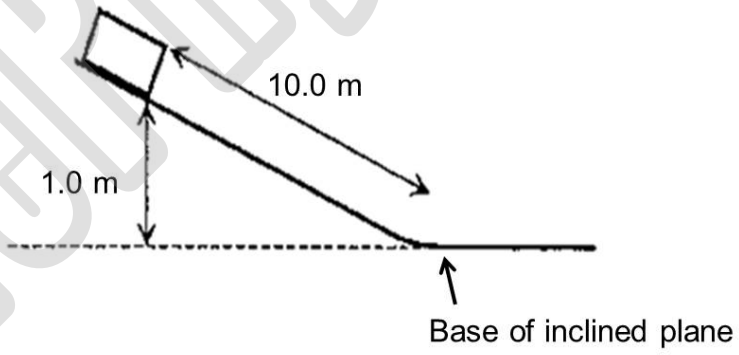
D There is no work done on the rice sack.

5 A motor driving a pump raises 0.10 m^3 of water through a vertical height of 5.0 m in a time of 10 minutes.

If the efficiency of the pump is 60%, what is the power generated by the motor? (Take the density of water to be 1000 kg m^{-3})

A 4.9 W **B** 8.2 W **C** 14 W **D** 82 W

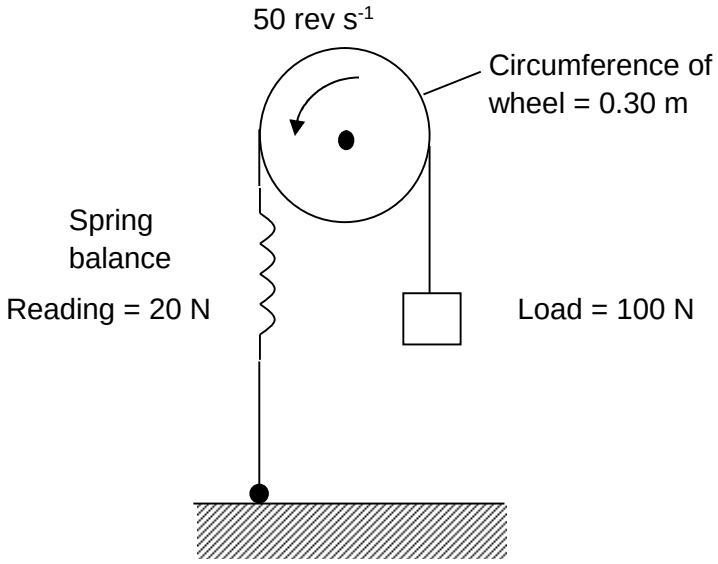
6 A body of mass 1.0 kg initially at rest slides down an inclined plane that is 1.0 m high and 10.0 m long as shown in the figure below.



If the body experiences a constant resistive force of 0.5 N while travelling on the slope, what is the kinetic energy of the body at the base of the plane?

A 4.8 J **B** 9.3 J **C** 10 J **D** 15 J

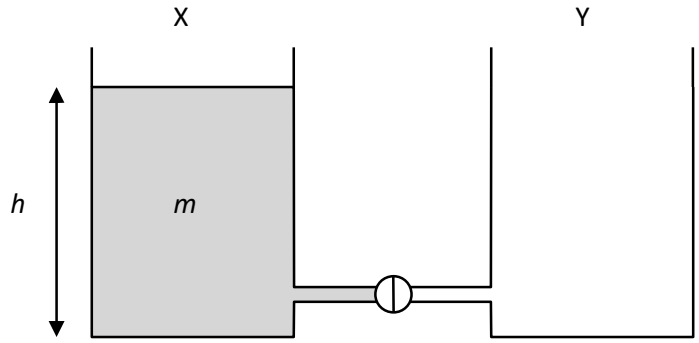
7 The figure shows a wheel which is driven by an electric motor. A rope is fastened at one end to a spring balance. The rope passes over the wheel and supports a freely hanging load. When the wheel is turning anticlockwise at a steady speed, the balance reading is constant.



What is the output power of the motor?

A 0.3 kW **B** 1.2 kW **C** 1.5 kW **D** 1.8 kW

8 The diagram shows two identical vessels X and Y connected by a short pipe with a tap.

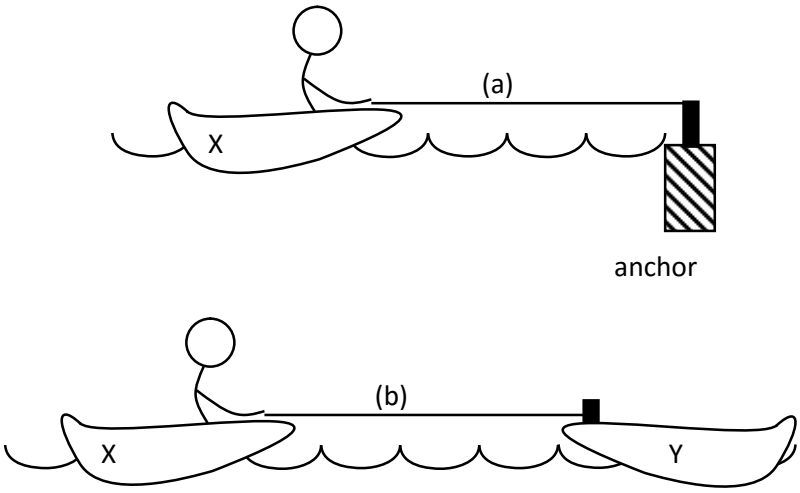


Initially, X is filled with water of mass *m* to a depth *h*, and Y is empty. When the tap is opened, water flows from X to Y until the depths of water in both vessels are equal.

How much potential energy is lost by the water during this process? (*g* = acceleration of free fall)

A 0 **B** $\frac{mgh}{4}$ **C** $\frac{mgh}{2}$ **D** mgh

9 A boy on a boat X pulls on a rope with a constant force *F* over a duration of time *t*. The other end of the rope is either tied to an anchor on (a) the pier or (b) a freely floating boat Y of equal mass as shown below.



W_a and W_b are the total work done by the boy during the time t whereas P_a and P_b are the average power output by the boy for case (a) and (b) respectively.

Which of the following is correct?

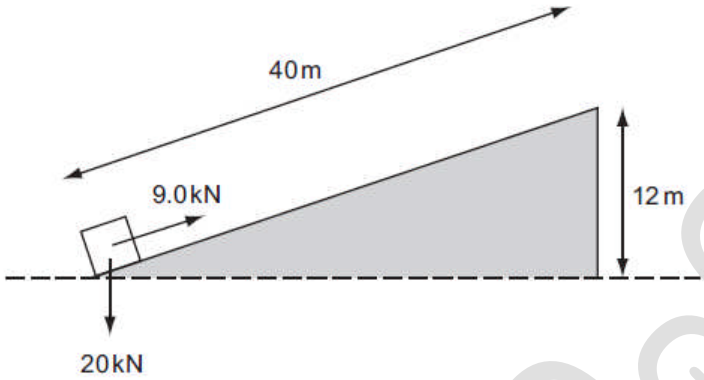
A $W_a > W_b$ and $P_a > P_b$

B $W_a = W_b$ and $P_a = P_b$

C $W_a < W_b$ and $P_a < P_b$

D $W_a > W_b$ and $P_a = P_b$

10 A constant force of 100 N, parallel to a rough inclined plane, moves a body of mass 20.0 kg at constant speed of 5.0 m s^{-1} through a distance of 40 m along the plane. The body gains a height of 12 m. Determine the magnitude of work done by friction that is dissipated as heat.

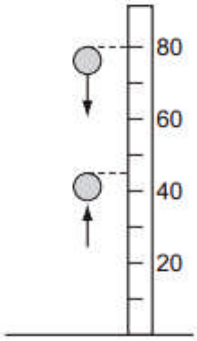


A 1.6 kJ **B** 2.4 kJ **C** 3.7 kJ **D** 4.0 kJ

11 A car of mass *m* has an engine that exerts a force of *F* on it. In a time *t*, the car travels a distance *s* and its speed increases from *u* to *v*. What is the useful output power of the engine?

A $\frac{Fs}{t}$ **B** $F(v-u)$ **C** Ft **D** $\frac{m(v^2-u^2)}{2t}$

12 A solid rubber ball has a diameter of 8.0 cm. It is released from rest with the top of the ball 80 cm above a horizontal surface. It falls vertically and then bounces back up so that the maximum height reached by the top of the ball is 45 cm, as shown.

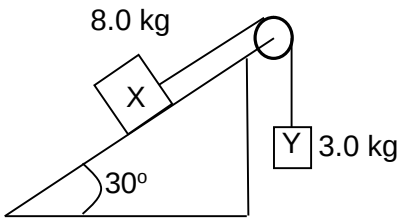


If the kinetic energy of the ball is 0.75 J just before it strikes the surface, what is its kinetic energy just after it leaves the surface?

A 0.36 J **B** 0.39 J **C** 0.40 J **D** 0.42 J

13 A system of two bodies X and Y weighing 8.0 kg and 3.0 kg respectively are connected by a light cord that is passed over a light-free running pulley, as shown below.

Starting from rest, X moves down a smooth plane inclined at 30° to the horizontal.



When X has travelled 2.0 m along the plane, what is the total kinetic energy of the system?

A 2.0 J

B 20 J

C 77 J

D 98 J

14 A pump draws a volume *X* of water up a vertical height *h* from a slow-moving river and discharges it through a nozzle with speed *v*. The entire process takes place in time *t*. The density of water is ρ.

Determine the effective power of the pump.

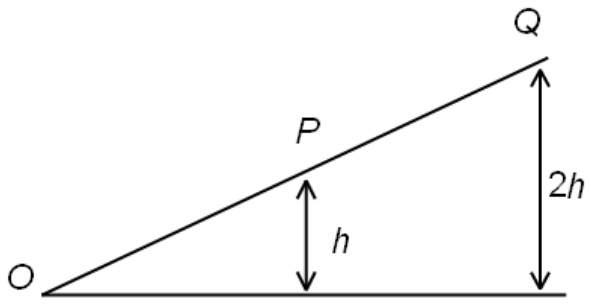
A $\dfrac{\rho Xgh}{t}$

B $\dfrac{\rho Xv^2}{2t}$

C $\dfrac{\rho Xgh + 2\rho Xv^2}{2t}$

D $\dfrac{2\rho Xgh + \rho Xv^2}{2t}$

15 A ball rolls down a smooth inclined plane. The ball is first released from rest from P and then later from Q. Which of the following statements is/are correct?



(1) The ball takes twice as much time to roll from Q to O as it does to roll from P and O.

(2) The acceleration of the ball at Q is twice as large as the acceleration at P.

(3) The ball has twice as much K.E. at O when rolling from Q as it does when rolling from P.

A (1) and (2) only

B (2) and (3) only

C (1) only

D (3) only

WORK.ENERGY.POWER
WORKED SOLUTIONS

Challenging **MCQ** questions by The Physics Cafe

Compiled and selected by The Physics Cafe

1 Ans: **C**
Recall the nature of *KE* and *EPE* graphs in SHM. *GPE* depends on reference point.

2 Ans: **C**
Power = $Fv = kv^3$

3 Ans: **B**
Power i/p = $\frac{1}{2} \rho A v^3$

4 Ans: **C**
Based on Energy Work Theorem and isolating rice sack as system,
Work done on rice sack by man + Work done on rice sack by gravity = Change in KE
Work done on rice sack by man = - Work done on rice sack by gravity
|Work done on rice sack by man| = |Work done on rice sack by gravity|

5 **Ans: C**
$P_{out} = 0.6 \times P_{in}$
$\frac{V\rho gh}{t} = 0.6 \times P_{in}$
$P_{in} = 13.6\ W = 14\ W$

6 Ans: **A**
Lost in G.P.E = Gain in K.E + Work against friction
1(1)(9.81) = K.E + 0.5(10)
K.E = 4.8 J

7 Ans: **B**

Treat the load and rope attached to load as one system, (assume massless rope)
To keep the load at a steady speed
tension due to spring balance + additional force due to wheel on the rope connected to load = mg
additional force due to wheel = 100 – 20 = 80 N
Velocity of rim of wheel = distance / time = circumference x 50 rev s^{-1}
= 0.30 x 50 = 15 m s^{-1}
Output power = Force x velocity = 80 N x 15 = 1200 W = 1.2 kW

8 Ans: **B**

9 Ans: **C**

10 Ans: **A**

11 Ans: **D**

12 Ans: **D**

KE before striking the surface = (GPE before releasing the ball) which is proportional to a height of 80 cm. = 0.75 J

KE just after leaving surface = (max GPE after bounce) which is proportional to a height of 45 cm.

Hence, by proportion of height,

KE just after leaving surface = (max GPE after bounce)/(GPE before releasing) x 0.75 J

= (45/80) x 0.75 = 0.42 J

13 Ans: **B**

Net loss in G.P.E = Net gain in K.E

Loss of G.P.E of X - gain in G.P.E of Y = Gain in K.E by system

$m_x g(2\sin 30^o) - m_y g(2)$ = Gain in K.E by system

Gain in K.E by system = 78.48 - 58.86 = 19.6 = 20 J (2 s.f.)

14 Ans: **D**

Effective power = total work done / time taken = $\frac{\rho Xgh + \frac{1}{2}\rho Xv^2}{t} = \frac{2\rho Xgh + \rho Xv^2}{2t}$

15 Ans: **D**

(1) Ball released from Q will arrive at some speed when it reaches point P, as a result, it will take shorter time to complete the remaining distance from P to Q. Hence the ball will take less than twice as much time to roll from Q to O as it does to roll from P and O.

(2) Since the gradient remains the same throughout the slope, resultant force acting on the ball remains the same, hence no change in the acceleration of the ball at point P and Q.

(3) Using principle of conservation of energy, gain in KE equals loss in GPE, since the height of Q is twice as compared to P, the ball has twice as much K.E. at O when rolling from Q as it does when rolling from P.