Mechanical Reasoning Test Solutions

Q A Explanation

1 C Switch 1 completes the circuit connecting A, C and D, and Switch 2 breaks the circuit which includes B and E.

2 B The weight will lower the rubber brace on the left, and this in turn will pivot the second log, forcing the second brace upwards, in turn raising the left end of the third log, lowering the right-hand brace.

3 D The greater the velocity of flow, the lower the pressure. This is called the Venturi effect, and it means that the air pressure within the tube will be lower than in the surrounding atmosphere, causing a corresponding increase in the water level.

4 B Gravity will cause the arrow to drop in flight, so it is always necessary to aim higher than the bullseye. The wind will force the arrow to the left, so to compensate the archer must aim slightly to the right.

5 C The period of a pendulum (the time it takes to complete a swing) is proportional to the length of the string, so the shortest pendulum will swing the fastest. Air resistance is proportional to the square of the velocity, meaning there would be a greater resistance to motion for pendulum C, and hence it would be slowed to rest the quickest.

6 D The stoppers in A do not stop the block spinning clockwise (at least for the first quarter turn or so). C has only one stopper which is preventing motion, which would not be as secure as two. While the stoppers in both B and D do not allow free movement, in B the stoppers are on the short ends, meaning that the direction of the turning force is only at 45° to the stopper. In D the stoppers are directly in the path of the turning force, meaning there is less chance of slippage.

7 B The time it takes to hit the ground is not affected by the weight of the objects (neglecting air resistance all objects accelerate at $9.81m/s^2$), but taking into account air resistance, which will slow the basketball down slightly more than the baseball, the baseball should land first.

8 B The cam on the left rotates about its centre, so rod A will remain the same height. The right hand cam rotates about an off-centre pivot, so will move up and down as the cam turns.

9 A The router bit cuts away wood from the edge, so the shape of the bit must match up alongside the shape of the moulding.

10 C Firstly, liquid is much harder to compress than gas, so if the bottle were completely full (of any liquid) it would be difficult to indent. Secondly, the more soda there is in the bottle, the greater the quantity of CO_2 it can produce, and thus the greater the pressure of the gas within the bottle.

11 B The fibres in A are all angled towards the plane, meaning the blade will have a tendency to get stuck. In B, the fibres are pointing in the direction of planing, so the plane is easier to control without the blade sticking and rucking up the wood. These situations are described as 'with the grain' and 'against the grain'.

12 C This is a ratchet - the teeth of the cog are angled so as to jam against the stop if forced to go in one direction, but to slip past easily if travelling in the other direction.

13 A When two wheels are connected by a belt, their direction can be determined by following the path of the belt. Unless it crosses over between one wheel and the next, the direction of motion will remain the same.

14 B The power source needs to be connected to both sides of Up, but no more than one side of Down (otherwise the circuit will be completed, and Down will be activated also).

15 D To remove most nuts, they must be turned counterclockwise. The further away from the nut, the greater the leverage.

16 D A, B and C all have their centre of mass directly above and in line with the axis of rotation. D is a less symmetrical shape, and its centre of mass is not in line with the axis of rotation, which will cause a wobble.

17 B When two objects collide, momentum is conserved. This means that the product of mass and velocity is the same. If the full trolley is twice the mass, say, of the empty one, to have the same momentum it can only be travelling at half the speed.

18 A The narrower the wheel, the lower the friction which is what eventually slows and stops a toy car. Increasing the weight of a vehicle won't make it faster, so that is not a factor.

19 B The force which cracks ice is pressure. For a given mass, pressure can be reduced by increasing the area of contact ('spreading your weight') in just the same way that reducing your area of contact (eg, wearing stiletto heels) will increase the pressure you exert. This is the principle upon which snowshoes work, spreading your weight across a larger area so you don't sink in.

20 C Not only is it the thinner of the two types of chain, but it also has a broken link.

21 A If a load is balanced on top of a pile of blocks, the weight will be supported ultimately by the ground, but via the parts of blocks which form a direct link between the object and the ground (in a vertical line). In B, D and C the load-bearing region is smaller than A due to blocks being moved out from the central line.

22 C A narrowing of a pipe for a given flow rate increases the velocity of the water, but reduces the pressure to compensate. A turn in a water pipe will require a change of direction which requires the action of a force (in this case, the reaction force of the pipe against the water) also reducing the pressure.

23 B A particularly large button hole will cause the button to slip out more easily, while a particularly small one will make it very difficult to attach in the first place, leaving B as the best compromise.

24 C The motion of the roundabout is continually forcing the child to turn, while the natural tendency of any body is to travel in a straight line. This manifests as a force pulling the child away from the centre. The further from the middle, the greater the distance they are being turned, and the greater the force they will experience.

25 B Gases compress much more easily than liquids, so although for B the downward motion of the left-hand piston will be almost matched by the upward motion of the right, in A and C the gas will be compressed, reducing the space within the chamber and reducing the necessity of the right-hand piston to rise.

26 B The force required to stop an object depends on both its mass and initial speed. The more massive the object, the greater the force required to bring it to a stop.

27 C The beaters mesh together like cogs - they cannot both rotate in the same direction, and one cannot move without the other.

28 C Point A is the pivot point, so it will not move. The handles will be forced together, however, compressing the spring below the pivot point.

29 A The inside track is slightly shorter than the outside track (imagine exaggerating the effect by adding concentric tracks closer and closer to the middle).

30 C When a car changes direction, an apparent force (centrifugal) is felt by occupants and objects - this is simply the tendency for objects to continue to travel in a straight line unless acted on by an external force. Eventually the force of friction with the dash or the side of the car will provide sufficient force for the ball to alter its direction.

31 C The dampener is a sponge or rubber pad which absorbs the movement energy of the cymbal, converting it to heat mostly. The larger the dampener, the more effectively - and rapidly - it can reduce the vibration to nil.

32 D The level of liquid will remain horizontal provided there are no forces other than gravity acting on it, even if its container is tipped.

33 D The furthest window, coupled with the extractor fan at the near end of the house, will create an airflow through the whole house. Any other window would leave some section of the house with no air pressure difference to correct, and so no circulation of air.

34 C The top of the casting system will be the hottest, since within molten steel, the hottest material will tend to move upwards. The coolest part is within the cooling pipes where billets are being formed (the outer shell will be solidifying while the core is still molten).

35 D A gradual slope makes for a smaller force, just applied over a greater distance, to produce the same result.

36 A The smallest cross-section will mean, for the same flow-rate, the water must be moving faster.

37 D The weight will be supported by friction of the plank with the tree. If the angle is steep, the moment of the force will be lower (the further you are from the pivot point, the greater the effect of your weight), and an upward sloping plank will be harder to dislodge from the tree.

38 B As the screw is turned, the jack becomes narrower and taller. This reduces the angle B and means A moves to the left.

39 C Adding holes to an oar will give it a smaller surface area, reducing the drag from the water (making it less effective as an oar, but, incidentally, reducing the tendency to twist from side-to-side).

40 C Gears interlock teeth, so when one turns clockwise, any connected to it turn counterclockwise. The cog to the left of A will turn counterclockwise, meaning the middle cog turns clockwise, meaning the top two also turn counterclockwise.

41 A In order to tip the containers sufficiently far to begin pouring liquid, they must be pivoted about the connection point. This would require less force for A, since a large portion of the contents is already above the pivot point, and so would help to counteract the weight of the water below. Also, since it is almost full, it only needs to be turned through a small angle.

42 C As the wheel turns, the connecting pin will be pulled to the left, travelling clockwise around the wheel. Half way around will be its furthest point to the left, and beyond that will begin to return to its original position.

43 B Assuming the tape moves at the same speed, unrolling from a wide circle requires fewer turns for the same length. This means that as the radius of the circle decreases, the speed of rotation must increase to compensate for the smaller circumference.

44 D The handles pivot at the right-most pin (where the handles come together), meaning the closer the ends of the handles the further the points L and M. And the upper head-section pivots on the upper left pin, lowering point E. The lower head-section pivots in the same way, raising point F.

45 C The first time the black pointer of Y is pointing left is after a ¾ turn. Since X rotates twice as fast, it will have turned 1½ times by this stage. After this turn, the black pointer on X is pointing right, and so they meet.

46 D T must be closed to complete any circuit, and if P is closed, bulbs 1, 2 and 3 will all be connected. Closing Q instead leaves out bulb 1.

47 B E will be at its highest when the other end of the bar is furthest to the left. This happens when the connecting rod is on the far side of the wheel.

48 D The top right end of the L-shaped handle will move in an arc up and left. The bar attached on the right forces the middle of the vertical bar outwards as it rises upwards. This moves the point "X" both up and to the left.

49 B The force which would normally send the mallet back upwards is transferred to the first layer of shot, and their upward momentum is transferred to the second layer - the first layer will bounce back and fall back to the base of the head while the momentum of the second layer is transferred on upwards. With many small ball bearings the impact has to move through many layers, and energy is lost in each collision as heat, sound and sideways motion, all of which reduce the final 'kick' of upwards motion. Also, the fact that the balls bounce back down will counteract the upwards force of other balls.

50 A Surrounding bottles with cold water or ice is clearly better than leaving them surrounded by simply air - water can store a lot of heat energy, and so takes more energy to return to ambient temperature. Water with ice, however, is better than just ice because the water bottles will be in direct contact with water and ice at freezing point, while just ice would mean a much lower contact area with the bottles, and a less effective heat sink.

51 D Since adjacent cogs must turn in opposite directions, any closed circuit comprising an odd number of cogs cannot turn.

52 C Small gaps between the holes is advantageous, since the shorter the distance paper has to tear the less chance of going off-track. But the larger the holes, the less paper there is to rip, and the easier it will be to tear the paper (although it may look less neat).

53 B Temperature is not the only thing that affects the boiling point of water - air pressure also plays a part. The higher the air pressure, the harder it is for water to vapourise, so the hotter the water must get before boiling (eg, in a pressure cooker). Conversely, the lower the air pressure, the easier it is for water to vapourise, and so water at the peak of a mountain might boil at temperatures as low as 85°C.

54 D Depending on which way round the board was cut (and which half was discarded), either of the two saws would do the job. The complementary angle to 120° is 60°.

55 D The casters will naturally lie so that their centre of mass is furthest back from the direction of travel (heavy things accelerate less easily than light things), so the wheels at the front would pivot until their centre of mass was the opposite side of their pivot point.

56 C The small plunger will decrease the volume of the water in that section of the system, correspondingly increasing the volume of water in the larger chamber. However, increasing the volume in a wider chamber will increase the height by a lesser amount due to the larger area.

57 C Any wheel attached by a belt in the usual way will turn the same way. If the belt is crossed over, it will reverse the direction. The two wheels on the left and the three on the right will all turn clockwise.

58 C The forces on a door have a tendency to twist the door at the pivot point - the hinges. The wider apart the hinges, the more they support the door, since they are closer to the potential points of turning force. Imagine a door with only one hinge in the middle - it would be prone to swinging outwards from the top or bottom, with a large turning force exerted on the hinges.

59 D Water at the base of the cylinder is under the most pressure, since it is under the weight of the water above. However, it has only a short distance to fall, and cannot travel far before hitting the ground. On the other hand, the water near the top, while under little pressure, has a longer distance to fall. The greatest range will come from water half way up - a compromise between the pressure required to give the water a greater velocity and the height required to maximise the range.

60 B The logs will dry the quickest if there is a good airflow between them, and if they are kept up off the ground. Pile B has the logs more spaced out, and it makes use of smaller logs on the bottom, widely spaced, to form a buffer between the large logs and the ground. While the small logs will dry more slowly than those above, by virtue of being small they will dry more quickly than the large logs on the base of pile A.